DYNAMICITY OF THE TECHNOLOGICAL INNOVATION SYSTEM AND THE TRANSACTION ATTRIBUTES IN CONTRACTUAL STRATEGIC ALLIANCES

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ABSTRACT

This study aimed to analyze the influence of the TIS dynamics in the attributes of transactions in alliances. To test the model, the analysis of structural equation modeling resolved by Partial Least Squares method was performed, using primary and secondary data. The results show that the dynamics of TIS is not enough, by itself, to change the nature of the attributes uncertainty and specificity of the assets involved in the transactions, but can positively influence the frequency of transactions. The paper presents theoretical and methodological implications, as well as for management practices.

Keywords: *Biotechnology, Innovation, Transaction*

1. INTRODUCTION

Technological advances in the pharmaceutical sector through biotechnology development, changes in demand and in the institutional environment drove companies to increase spending on research and development, innovative processes and new forms of management (POWELL, et al., 2005). Biotechnology is characterized as an area of knowledge marked by multi-disciplinarity for creation, diffusion and use of products and technologies, demanding interaction among agents - government, private companies, research foundations and universities - for their development based on strategic alliances run by relational contracts that promote the sharing of complementary capacities (EDQUIST, 1997). The capacities required from these companies can no longer be developed in isolation, depending on their central performance in the strategic alliance network (POWELL, et al., 1999).

On the other hand, as explained by Powell; Packlen; Whittington (2012), the biotechnology industry has developed from agglomerates or regional blocs. Considering the strategic importance of this industry and the need for a more in-depth understanding of the dynamics of its development, this study aims to explore the relation between the biotechnology TIS, considered at the regional level, and the transaction attributes in strategic alliances for developing new products. The intent is to thus move forward towards providing a theoretical reference framework that integrates organizational economics approaches and innovation systems, based on the constructs alliance transaction and TIS, which favors the improvement of advanced alliance management techniques for developing new products and public policies for sector development.

The paper begins reviewing literature on biotechnology TIS, at the regional level, and the transaction attributes, listing these constructs based o hypotheses that constitute the structural model. Then, the methods used for measurement and for statistical testing of the model are presented. Finally, the analysis of results and conclusions are presented.

2. THE RELATION BETWEEN BIOTECHNOLOGY TIS AND TRANSACTION ATTRIBUTES

The regionality, that is, the set of economic, social, geographic location, cultural and landscape factors that characterize a region, is of utmost importance for possible productive development (; DI BENEDETTO; DESARBO; SONG, 2008). However, only geographic location is not sufficient for generating development. An institutional structure is also needed, formed from the interaction of agents, so knowledge can grow and be disseminated (FLORIDA, 1995).

The different interactions among institutions, companies and government in a field of specific knowledge and how each of these agents behaves in relation to the creation, diffusion and use of knowledge, recognizing theoretical problems and developing new concepts and solutions, constitute the Technological Innovation System (TIS), considered at the regional analysis level (AUTIO; HAMERI, 1995; CARLSSON, 1997).

The structure and dynamics of technological change vary considerably over time and in different domains, modifying how institutions and economic organizations act (CARLSSON, et. al. 2002). In this study, TIS' dynamicity will be characterized by an increase in the intensity of activities developed in the generation and dissemination of knowledge in the biotechnology industry from 2002 to 2012. These activities are represented by the evolution of cognitive structures such as the increase in the number of papers published in this area, the increase in the number of patent deposits and grants, among others, and organizational/institutional structures, through an increase in research groups, greater investment in promoting and granting research scholarships, etc.

Mackinnon (2008) defends the theory that the regions are capable of shaping their own perspectives for development, based on rapid technological changes and an increase in capital mobility.

On the other hand, transactions between organizations may be characterized by attributes that influence their costs: uncertainty, asset specificity and frequency (WILLIANSOM, 1991). These concepts are then developed, relating them to regional biotechnology TIS.

Williamson (1985) characterizes uncertainty three ways: (1) primary uncertainty, which is linked to environmental contingencies related to technological and market variations; (2) secondary uncertainty, related to information asymmetry regarding managerial decision taken by competitors, and finally (3) strategic uncertainty, related to limited rationality and to opportunism used to distort, cover up or mask information.

For Santoro; McGill (2005) and McGill; Santoro (2009) uncertainty in transactions governed by strategic alliances can be classified three ways: (1) technological uncertainty, (2) uncertainty related to partners, and (3) uncertainty in task execution and control. Technological uncertainty is tied to the fact that changes in the use or evolution of a given technology make it irrelevant in the technological system. Uncertainty related to partners is tied to knowledge of their capacities and trust, influenced by mutual experience. Uncertainty related to tasks is characterized by concerns relative to the possibility of controlling the progress of activities tied to the alliance. Regardless of the type of uncertainty, this tends to diminish as the volume of available information increases.

According to Ahmad; Mallick; Schroeder (2013), the degree of uncertainty related to new products developed through alliances is directly tied to the degree of interaction among partners. The greater the uncertainty, the greater will be the need for integration, monitoring and control of partners and of activities in a strategic alliance. Gulati; Nickerson (2008) underscore that the existence of interorganizational trust leads to an increase in expectations in new alliances and also a reduction in control using formal mechanisms in alliances.

The increase in activity dynamics in the regional TIS leads to an increase in information available based on the training and qualification of regional labor, the emergence of incubators and startups, events, courses and consultancies for technological dissemination. Interactions among the region's organizations also increase, whether through joint activities in regional sectorial associations or strategic alliances, consequently generating mutual experience and knowledge among partners, thus reducing uncertainty in the regional innovation system (ERNST; LICHTENTHALER; VOGT, 2011). Based on this reasoning, it can be argued that:

> **Hypothesis 1 (H1) –** Greater dynamicity of regional biotechnology TIS favors a reduction in uncertainty related to partners, tasks and technology in the contractual strategic alliances between agents.

The degree of asset specificity is related to cost and the possibility of using these assets in other activities not tied to the transaction (RIORDAN; WILLIAMSON, 1985). As the degree of specificity increases for an asset in a transaction, unrecoverable costs increase in the case of breaking a transaction. Thus, the greater the asset's specificity, the greater its importance in transactions. Williamson (1985) describes the following categories of specificities: (a) locations specificity; (b) human asset specificity; (c) dedicated assets; (d) physical asset specificity; and (e) temporal specificity.

As underscored by Carlsson (1997), the knowledge required for satisfactory exploration of opportunities in the biotechnology industry is highly specific. In strategic alliances in the regional biotechnology TIS two of the main assets are knowledge and human skills (ERNST; LICHTENTHALER; VOGT, 2011).

The increase in the dynamics of training and qualification activities for labor and technological diffusion in the regional biotechnology TIS leads to greater specificity in strategic alliances. Technological diffusion and organizational integration activities, such as joint development of studies and investments, establishing technological guidelines, organizing technological events at a regional level, lead to greater integration of the various subjects and areas of knowledge involved, generation of productive innovative processes and development of specialized resources. This thus increases the specificity of physical and human assets tied to strategic alliances, that is, alliances for performing joint activities, such as manufacturing, research, R&D, sales, supplies, etc., without shareholder participation between parties and governed by relational contracts (MÉNARD, 2006). In this sense, it can be argued that:

> **Hypothesis 2 (H2) –** greater dynamicity of the regional biotechnology TIS favors an increase in asset specificity involved in contractual strategic alliance transactions among agents.

The frequency of a transaction is associated with the number of times agents perform it. Some occur in a single point of time, whereas others are recurrent. The greater the frequency of a transaction, the smaller will be the chance for opportunistic behavior that could imply its interruption and, consequently, the loss of future gains derived from exchanges (WILLIAMSON, 1985). Repetitiveness in transactions permits creating reputation between links, leading to the reduction in ex-post modifications in contracts, which, consequently, also reduces preparation and monitoring costs.

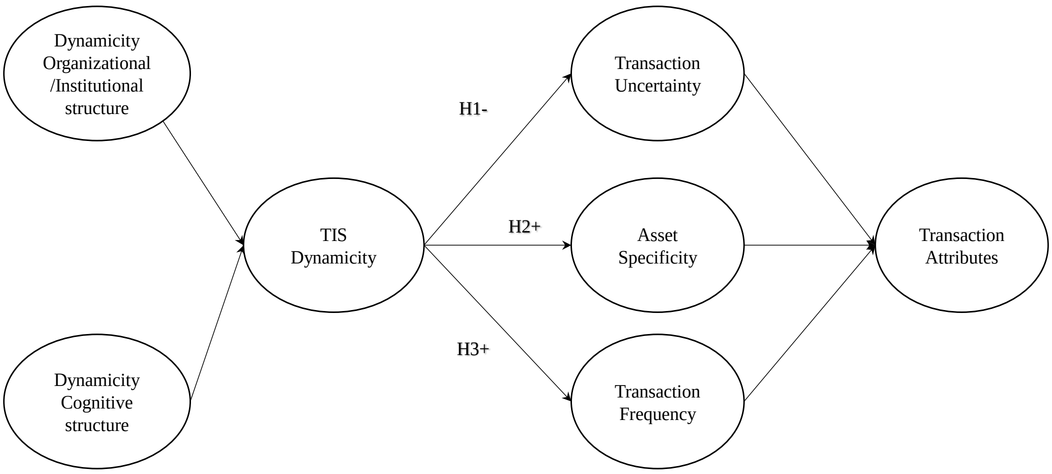
The increase in the dynamics of integration activities of organizations in the regional biotechnology TIS motivated by local sectorial associations, government agencies, public investment programs for innovation that value partnerships and qualification of labor, raises the interactions between the region's organizations via joint activities within the ambit of the associations and regional government agencies and contractual strategic alliances between the agents. This generates experience and mutual knowledge that reduce uncertainty in relation to partners, raising the degree of interorganizational trust and minimizing alliance transaction costs through the decrease in spending on the search for information, the creation of safeguards and the creation of mechanisms of control over projected tasks in the contracts. This diminishes *ex-ante* and *ex-post* costs, and feeds new interactions and alliances (ERNST; LICHTENTHALER; VOGT, 2011). Based on this reasoning, it can be argued that:

> **Hypothesis 3 (H3):** Greater dynamicity of regional biotechnology TIS provides greater recurrence of contractual strategic alliance transactions between agents.

3. METHODOLOGY

Figure 1 shows the measurement model developed for testing causal relations proposed by the hypotheses developed.

Figure 1: Model for testing proposed relations.



Source: Elaborated by the authors.

The TIS construct described by Carlsson; Stankiewicz (1995) is comprised of three first-order latent variables: cognitive structure, organizational/institutional structure and economic structure. The first two variables are directly tied to organizational activities, whereas the economic structure is tied to demand. The demand for biotechnology products is an indicator that does not present differentiation at the regional level. Thus, the TIS construct was modeled in a reflexive manner, believing that a change in the TIS construct would cause changes in latent variables: cognitive structure and organizational/institutional structure. Table 1 shows the observable variables associated with these latent variables.

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Table 1: Dynamicity Construct of the Technological Innovation System, latent and observable variables of the measurement model.

Construct	Latent Variable	Observable Variable
TIS Dynamicity	Cognitive Structure	Papers: number of papers published in Biotechnology
		Theses: number of PhD theses
		Dissertations: number of Master's dissertations
		Patents: number of patent deposits by companies with IPCs related to biotechnology
	Organizational/ Institutional Structure	Undergraduate: number of undergraduate courses
		Research Groups: number of research groups focusing on applications in biotechnological products and processes
		Master’s/PhD: number of academic and professional Master's courses and PhDs in Biotechnology
		Sponsorship: sponsorship of CNPq in science, technology and innovation
		Scholarship: CNPq investment in research scholarships related to studies in biotechnology

Source: Elaborated by the authors.

The **cognitive structure** is comprised of observable variables that represent the dissemination of knowledge in industry. For this latent variable, the observable variables are: number of scientific papers published in Biotechnology (Papers); number of PhD theses (Theses); number of Master's dissertations (Dissertations) and number of patent deposits, by companies with International Patent Classifications - ICPs - related to biotechnology (Patents). The data were used in Ministry of Education and National Institute of Intellectual Property (INPI) databases, Institute for Scientific Information (ISI) databases and Brazilian Federal Agency for Support and Evaluation of Graduate Education thesis and dissertation database.

The **organizational/institutional structure** is represented by observable variables tied to knowledge generation. For this latent variable, the observable variables were: number of undergraduate courses (Undergraduate programs); number of research groups focusing on applications in biotechnological products and processes (Research Groups); number of academic and professional Master's courses and PhDs in Biotechnology (Master’s/PhD); sponsorship of the National Council on Scientific and Technological Development (CNPq) in science, technology and innovation (Sponsorship) and CNPq investment in research scholarships related to studies in biotechnology (Scholarship). The data were collected from Ministry of Education databases, the Ministry of Science and Technology and the Brazilian Federal Agency for Support and Evaluation of Graduate Education database (Table 2).

Table 2: Description of the secondary data collection process used for characterizing the biotechnology TIS.

Latent Variable	Variable Observable	Source
Cognitive Structure (Knowledge Dissemination)	Theses and Dissertations in Biotechnology	The information on theses and dissertations was collected from the Brazilian Federal Agency for Support and Evaluation of Graduate Education (Capes) thesis and dissertation database. Three filters were used for data identification: the distinction between theses and dissertations; the "subject", fixed for both levels in terms of biotechnology; the "base year for the survey", 2002 to 2012 was used.
	Papers published	The data for this indicator were collected in the Institute for Scientific Information (ISI) database. The filters used were: terms - "biotecnologia" and "Biotechnology". These terms were entered in the "Topic" and "Title" fields; another filter used was survey time used in the last five (5) years; only papers were searched and for country/territory, only "Brazil" was chosen. The selected papers were grouped by state.
	Patents deposited	Raising information from the National Institute of Industrial Property - INPI website. The International Patent Classification (IPC) Codes corresponding to the patents published by the OECD were used for this indicator, with the following codes: A01H; A61K; C12N; C12P; C12Q, and G01N.

Organizational/institutional structure (Knowledge generation)	Number of undergraduate courses in biotechnology	E-MEC available on the Ministry of Education website. This system offers the possibility for searching for Institutes of Higher Education and for registered courses. The filters used were: term biotechnology; situation; in activity, and modality: distance and presential, and degree: Bachelor's, Teaching, technological and sequential.
	Research groups (research lines - biotechnological products and processes)	Lattes platform – - research group directories – censuses. The option was for research lines, since it is the only means of directly selecting data tied to biotechnology. The application sector was selected: Biotechnological products and processes. After that filter, the division by states was made. The number of groups associated with a Sector corresponds to total groups that develop at least one line of research related to that Sector.
	Master's and PhD programs in biotechnology	CAPES Directories. Number of courses recommended and recognized by CAPES for the large area: multidisciplinary and evaluation area: biotechnology. After identifying this database, courses related to study regions were selected.
	CNPq investment in Sponsorship of ST&I and research scholarships	National Council for Scientific and Technological Development "Statistics and Indicators" database. The "Historical Series" link was accessed specifically, and then the CNPq link in the States. The selected filters were: first filter, the choice of "Knowledge area", which, in this case was Biotechnology; second filter was the choice of the year in study, opting for 2010.

Source: Elaborated by the authors.

Most of the strategic alliances in the biotechnology industry were established only after approval of Decree 1752/1995, which establishes rules for using biotechnology by the Brazilian production sector (ODA; SOAREZ, 2001), with more data on them after 2000. Thus, the data were collected from 2002 to 2012 making it possible to obtain a historical series for each observable variable. With these series of data, regression analysis was processed to obtain the values related to the slope coefficient (β), which expresses the tendency of each indicator in the period of interest, serving as an input value for Structural Equation Modeling – *Partial Least Square* (SEM-PLS) using *Smart -PLS* 2.0 M3 software.

The population studied is comprised of companies that operate in the biotechnology segment for human health, located in the five (5) states with the greatest concentration of companies in this industry. According to Biominas (2011), the states with the highest concentration are: São Paulo, Minas Gerais, Rio de Janeiro, Paraná and Rio Grande do Sul. These states together correspond to approximately 85% of the companies that comprise the biotechnology industry in Brazil. A database was elaborated with information on these companies.

In this work, the Transaction Attributes construct is characterized by three latent variables: transaction frequency, transaction uncertainty and asset specificity (WILLIAMSON, 1991), modeled as formative, since variations in the first-order latent variables would cause changes in the construct.

The latent variable **transaction uncertainty** is characterized pursuant to Santoro; McGill (2005) as comprised of three first-order latent variables: market uncertainty, task uncertainty and partner-related uncertainty. This latent variable was modeled in a reflexive manner, believing that when there is a variation in its composition, this will affect first-order variables directly. The observable indicators for the **transaction uncertainty** dimension are: capacity to make adjustments; trust; similarity in competences; organizational culture, national culture; technological stage; complexity of the technological knowledge base; technological instability and market instability.

The latent variable **asset specificity**, according to Santoro; McGill (2005) is characterized by three first-order latent variables: **physical assets, location assets and human assets.** This latent variable was modeled in a reflexive manner, believing that when there is a variation in its composition, this will affect first-order variables directly. Therefore, for this dimension, the following manifest variables were used: new and specific resources; adaptation of processes; recovery of investments; specific knowledge; training; investment in human assets; physical locations and recoverable location investments. The reason for not raising information about dedicated assets is based on the fact that the knowledge generated by this knowledge area may be used in other areas, justifying the multidisciplinary nature of biotechnology.

The **frequency of transactions** is associated with the number of times agents perform them. Some occur in a single point of time, whereas others are recurrent. The greater the frequency of a transaction, the smaller will be the chance for opportunistic behavior that could imply its interruption and, consequently, the loss of future gains derived from exchanges (WILLIAMSON, 1985). The following manifest variables were used for this latent variable: repetition of partnerships; specific technological experience and prior relations with the partner.

The second data collection phase, relative to transaction attributes, occurred through the raising of primary data. After organizing a database of potential companies that would participate in the study, defined by the universe described above, after contact with state employers' unions from the pharmaceutical sector, data began to be collected: (1) there was initial contact with the companies to identify the person most indicated to participate in the survey; (2) then, an e-mail was sent with an invitation letter for that person, requesting his/her participation in the survey; (3) after accepting to participate, an e-mail was sent with a link for the respondent to have access to the questionnaire and to complete it; (4) if problems were detected in completing the questionnaire, the researchers contacted those interviewed to explain any existing doubts.

The interviewed managers were invited to choose an alliance to answer the questionnaire, the activities of which began no more than 3 years ago and that had been concluded no more than 1 year ago. The data collection instrument used is comprised of questions relative to the transaction attributes construct. The questionnaire is structured with a Likert agreement scale ranging from 1 (totally disagree) to 5 (totally agree) and it was validated using a pre-test with three executives specialists in the sector, with at least 15 years of experience and tied to sectorial organizations.

The data analysis process was divided into two phases: the descriptive analysis of data and, later, structural equation modeling (SEM) using the Partial Least Squares (PLS) method, in order to detect and to establish existing relations between the thesis' main constructs. The statistical analysis of data and the SEM analysis were conducting using *SPSS,* version 17.0 and *SMARTPLS,* version 2.0 M3 software (RINGLE; WENDE; WILL, 2005). The parameters for the factorial loads of the measuring model and the structural coefficients were determined using *G*POWER* 3.0 software, with the *Post hoc test.*

The tests used to test validity (convergent and discriminant), reliability and consistency were: Average Variance Extracted (AVE) equal to or greater than 0.5 and Composite Reliability equal to or greater than 0.7. In relation to discriminant validity, the Fornell criteria were followed; Larcker (1981), using the square root of AVE, which should be greater than the correlations between the other constructs. The model's level of significance was analyzed using the Bootstrapping technique with 1000 re-samplings in 51 cases (CHIN, 1998). The significance level was defined at 5% (HAIR et al., 2009).

4. RESULTS

As explained in the methodology section, a database was created with 271 companies of interest in the target states. All the companies were invited to participate in the survey via an invitation sent by e-mail. Of that total, only 51 companies, approximately 19%, accepted to participate in the survey. Of the surveyed companies, 68.6% focused their activities only on the biotechnology industry, 5% are research institutes, whereas 21.6% are characterized by several activities directly tied to the biotechnology industry for human health and the pharmaceutical sector in general (molecular biology; pharmaceutical and biotechnology laboratory; pharmacochemistry and biotechnology, biotechnology and medications among other configurations).

In relation to size, year founded and shareholder control of surveyed companies, 66.7% reported having fewer than 50 employees, whereas 23.5% have between 50 and 500 employees. 45.1% of these companies are located in the state of São Paulo, 33.3% in Minas Gerais, 5.9% in Rio de Janeiro, 7.8% Paraná and 7.8% in Rio Grande do Sul. 76.5% of the companies began activities (year founded) after 1995. This configuration reveals an industry comprised of young, micro and small companies, most of which (94.1%) with national shareholder control; 20% did not answer the question.

In relation to answering managers, 45.1% are the company's principal executive and 62.8% have been at the company under 10 years. When asked about their involvement with the alliances, the majority (55%) classified themselves as Principal Executive or as Director (of research and development, knowledge management, new business and manufacturing) (Table 3).

Table 3: Characterization of respondent managers.

		Quantity	Percentage (%)
Hierarchical level	Principal executive	23	45.1
	Reports to the principal executive	19	37.3
	Reports to the executive who reports to the principal executive	6	11.8
	Intermediate management	1	2.0
	Operational management	2	3.9
How long working at the company (in years)	> 10 years	32	62.8
	< 10 years	19	37.2

Source: Elaborated by the authors from survey data

In relation to the alliances, the 84.3% formalized the start between 2000 and 2012, corroborating the youth character of the companies that operate in this sector. 15.7% of the alliances had their activities formalized before 2000. Of the alliances studied, only 10% ended, whereas 80% are still active. These data show that the alliances formalized in this industry are signed for the mid and long term. 51% of the alliances are for research and development (Table 4).

Table 4: Types of strategic alliances formalized by sampled companies.

Types of alliances	Quantity	Percentage (%)
Supply or distribution or sales	10	19.6
Manufacturing	4	7.8
R&D - research and development	26	51
Clinical Trial	5	9.8
Others	6	11.8

Source: Elaborated by the authors from survey data

The types of alliance classified as others were distributed among quality control of acquired products, R&D, clinical trial and research only. The number of partners in the alliances was also checked - in this case, interviewed companies should be considered in the count as well, thus the minimum number of partners would be two. 45.1% reported having only one partner (besides the company itself), 49% have 3 to 8 partners, whereas 5.9% have more than 9 partners in the studied alliance.

5.ANALYSES OF TIS DYNAMICITY RELATIONS AND TRANSACTION ATTRIBUTES

The model (Figure 2) shows that the variability in Transaction Uncertainty is explained in 0.1% by the TIS construct, and it also demonstrates that there is a negative, but significant relation (β= -0.024). This shows that when the TIS increases its dynamicity, there will be a reduction in transaction uncertainty in the biotechnology industry at the regional level. Observe that even when presenting an effect of the relation as proposed by theory, the structural load was not significant, remaining below the minimum acceptable for β ($\beta \geq 0.3072$). Even demonstrating convergent and discriminant validity, the relation did not prove statistically significant with a Student t value under 1.96 (t=0.371), thus rejecting hypothesis 1 of the study.

The second hypothesis (H2) proposes a positive influence of dynamicity of the Technological Innovation System in Asset Specificity. In this case, the variability of Asset Specificity is explained in 0.8% by TIS Dynamicity. This relation proved positive, as per the effect proposed by the theory; however, it was not significant (β=0091). However, the structural load was not significant, remaining below the minimum acceptable for β ($\beta \geq 0.3072$).

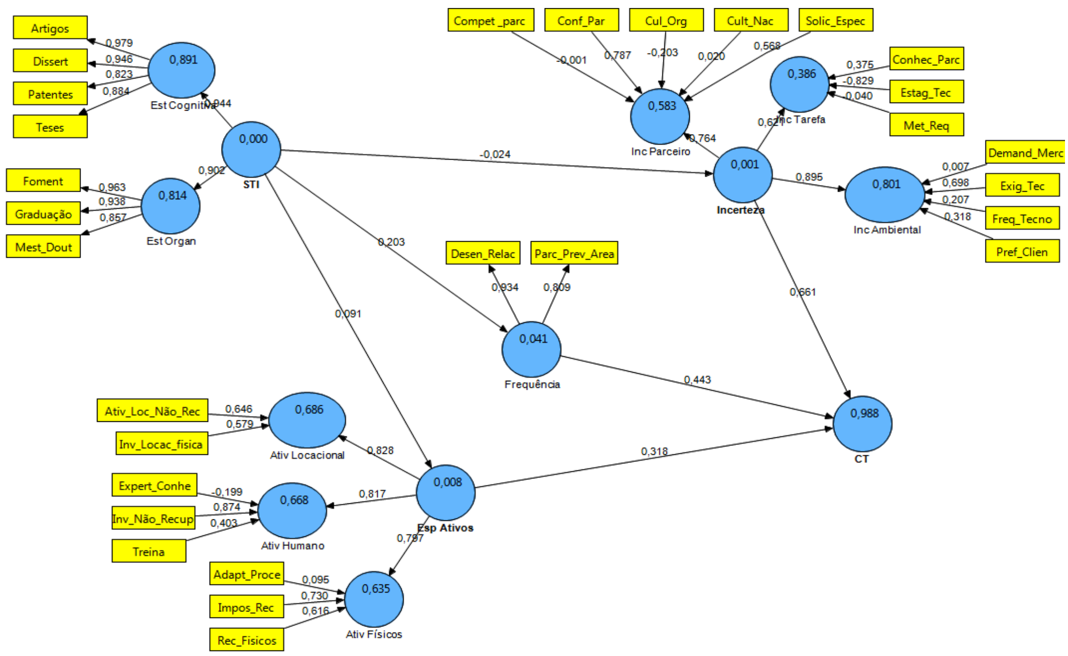
The results show that the model gathers convergent and discriminant validity, but they do not prove statistically significant, because they have a Student t statistical value below the standard required (t=1.318), rejecting hypothesis two proposed in the study. The justification for rejecting H1 and H2 may be in the number of studied cases (N=51), in the high number of variables used to measure the model and also in the fact that TIS Dynamicity itself is not sufficient for changing the nature of uncertainty and asset specificity attributes in contractual strategic alliances.

The third hypothesis (H3) tested proposes that TIS dynamicity influences the frequency of transactions of a contractual strategic alliance between agents in a positive manner. The analyses demonstrated that the variability of transaction frequency is explained in 4.1% by the TIS dynamicity construct. They also demonstrated that there is a positive relation (β= 0.203). The structural load value β (regressions) below the accepted value, through the analysis obtained by G*Power, may be related to the low number of cases studied.

With regard to the Bootstrapping significance test, the Student t statistical result proved significant (t=2.634) with a p value < 0.005, making it possible to accept hypothesis 3 as true; thus, when the TIS increases its dynamicity, there will also be an increase in recurring transactions in contractual strategic alliances.

Since the Transaction uncertainty, Asset specificity and Transaction frequency constructs are formation constructs for Transaction attributes (CT), there was the need to process the SEM-PLS involving the TIS Dynamicity and Transaction Attributes constructs. Figure 2 shows how relations between the TIS construct and the formation variables for the CT construct behave, in a broad manner, as well as the relationship of these variables with the construct itself. The data show that even with the inclusion of the Transaction Attributes construct, relations between the constructs maintain the same meaning, in an individualized manner: (1) when TIS dynamicity increases, transaction uncertainty decreases (β=-0.024); (2) when TIS dynamicity increases, there is also an increase in asset specificity (β=0.091), and (3) when there is an increase in TIS dynamicity, transaction frequency tends to increase (β=0.203). Even when not reaching the minimum value for factorial loads (β ≥ 0.3072), the relations had a consistent effect with the theory.

Figure 2: Relations between TIS Dynamicity and Transaction Attributes



Source: Elaborated by the authors from survey data

With the objective of checking the convergent validity of the model presented, AVE and Compound Reliability analyses were conducted. It should be pointed out here that to calculate AVE (used when factorial loads are standardized) and compound reliability for second order constructs, the following formulas were used:

Equation 1: AVE and Compound Reliability value calculation for second order variables.

$$AVE = \frac{\lambda_i^2}{\text{variables number}}$$

$$Conf = \frac{(\Sigma\lambda_i)^2}{(\Sigma\lambda_i)^2 + \Sigma\,\mathrm{var}(\varepsilon_i)} \qquad \mathrm{var}(\varepsilon_i) = 1 - \lambda_i^2$$

Obs.: λ = factorial loads among variables; Var. (ε) variance of error; Rel. = Compound Reliability.
Source: Chin (1998); Fornell; Larcker (1981).

As illustrated in Table 5, the results show that the model has convergent validity since AVE and Reliability values were higher than the parameters adopted in the study and suggested by Hair et al. (2009) (AVE> 0.5 and Compound Reliability > 0.7). Except for the Transaction Attributes construct, which present an AVE = 0.222. However, this value did not harm the model's convergent validity, since it is not necessary for all loads to be higher for the parameters established (CHIN, 1998).

Table 5: Adjustment measures for the relationship between Dynamicity of the TIS and Transaction Attributes/

	AVE	Compound Reliability
Physical Assets	n.a.	n.a.
Human Assets	n.a.	n.a.
Location Assets	n.a.	n.a.
Transaction Cost	0.222	0.664
Asset Specificity	0.663	0.855
Cognitive Structure	0.828	0.951
Organizational/Institutional Structure	0.847	0.943
Frequency	0.763	0.865
Market Uncertainty	n.a.	n.a.
Partner Uncertainty	n.a.	n.a.
Task Uncertainty	n.a.	n.a.
Uncertainty	0.590	0.809
TIS	0.715	0.946

Source: Elaborated by the authors from survey data

With the objective of affirming model reliability and consistency in its measurement, discriminant validity analysis was conducted using the values obtained by the correlations compared to the AVE square root values. As illustrated in Table 10, the results of AVE correlations and roots meet the parameters suggested by Fornell; Larcker (1981). Therefore, based on the results, it is possible to verify that the model is reliable and consistent in its measurement (Table 6).

Table 6: AVE correlations and roots for the Dynamicity of TIS and Transaction Attributes constructs.

	Transaction Cost	Asset Specificity	Cognitive Structure	Organizational/Institutional Structure	Frequency	Uncertainty	TIS
Transaction Cost	**0.471**						
Asset Specificity	0.398	**0.814**					
Cognitive Structure	0.075	0.102	**0.910**				
Organizational/Institutional Structure	0.142	0.061	0.709	**0.920**			
Frequency	0.716	0.137	0.161	0.222	**0.873**		
Uncertainty	0.823	0.028	-0.067	0.036	0.347	**0.769**	
TIS	0.113	0.091	0.901	0.902	0.203	-0.024	**0.846**

Source: Elaborated by the authors from survey data

These relations were tested using the Student t test with Bootstrapping with 51 cases and 1000 resamplings, with the objective of checking statistical significance in the model. The results illustrated in Figure 3 show that the relation between the TIS construct and the Frequency of transactions remained statistically significant (t= 2.634) with p-value < 0.001.

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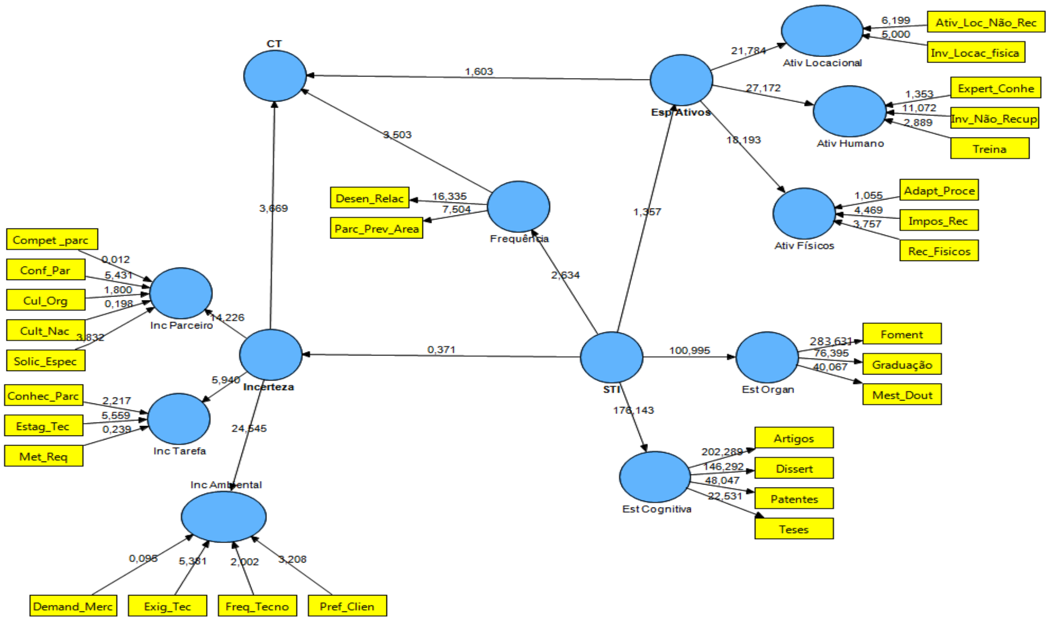
Figure 3: Student "t" statistics for the relationship between Dynamicity of the TIS and Transaction Attributes.



Bootstrapping with N=51 and 1000 resamplings.
Source: Elaborated by the authors from survey data

6. DISCUSSION OF RESULTS

After the construct validity tests, the hypotheses for this study were tested. Results confirmed the hypothesis of relationship between TIS and Frequency of Transactions (H3) and they rejected the hypotheses of relationship between TIS and Transaction uncertainty (H1) and TIS and Asset specificity (H2) (Table 7).

Table 7: Summary of results obtained from SEM-PLS analyses.

Hypotheses	Proposed effect	Structural Coefficients	t value	p-value	Support for the hypothesis
H1: TIS→Transaction uncertainty	-	-0.062	0.913	0.183	No
H2: TIS →Asset specificity	+	0.087	1.318	0.097	No
H3: TIS→Transaction frequency	+	0.202	2.786	0.004	Yes

Source: Elaborated by the authors from survey data

The proposal for hypothesis 1 is negative, since an increase in dynamicity of the Technological Innovation System will result in the reduction of transaction uncertainty, consequence of the increase in information availability in the market. However, for the sample studied in the biotechnology industry for human health, the hypothesis of a relationship between TIS and Transaction Uncertainty was not statistically significant. This non significance may be directly tied to sample size used in the study (N=5), which also has a direct tie with the number of variables used to measure the model. Another possible explanation for rejection of hypothesis 1 may be in the fact that the TIS itself cannot change the nature (WILLIAMSON, 1085) of uncertainty related to productive technology and to the market (SILVA; NALDIS, 2012).

Hypothesis 2 of the study suggests a positive effect of TIS dynamicity on asset specificity in transactions. However, the relationship between TIS dynamicity and asset specificity was not confirmed. Although the influence detected was present in the sense of the formulated hypothesis, there was no significance. According to Ernest; Lichtenthaler; Vogt (2011), the main assets in industries like biotechnology are knowledge and human skills, a fact corroborated by Carlsson (1997) and Powell; Packalen; Whittington (2012). This result may indicate that the specialization generated in labor does not tie it to a given transaction of a specific alliance, and it may be reallocated to other transactions. According to Williamson (1985), asset specificity is tied directly to substantial loss of value, when there is a rupture of contract relations between companies.

Hypothesis 3, which proposes a positive influence of the dynamicity of the technological innovation system on the recurrence of transactions, proved to be significant. For Williamson (1985), the recurrence of transactions is directly related to a reduction in opportunistic behavior, which permits the creation of reputation between links, leading to a reduction in ex-post modifications in contracts. Complementing that position, Gulati; Nickerson (2008) reported that the recurrence of transactions raises the degree of interorganizational confidence and minimizes alliance transaction costs. This occurs when there is a reduction in spending on the search for information, creating safeguards and control mechanisms over tasks projected in the contracts.

7. CONCLUSION

The objective of this paper was to explore the relationship between the biotechnology industry TIS, considered at the regional level, and the transaction attributes of contractual strategic alliances. The data were collected in a temporal perspective to characterize the Dynamicity of the Technological Innovation System construct, whereas the data for characterizing the Transaction Attributes construct were collected in a single moment, since it is the identification of information related to a given strategic alliance contract.

A theoretical implication of the study is that the greater the dynamicity of the TIS at the regional level, the greater the probability will be for the recurrence of transactions in the industry. This greater recurrence is tied to the knowledge the managers acquire from their partners and the experiences they accumulate with participation in strategic alliances, which will be activated in the formation of new alliances.

Another theoretical implication is that it seems the TIS itself is unable to change the nature of transaction uncertainty. Results showed that the dynamicity of the TIS provides a reduction in uncertainty related to the partner, but not in technological and market uncertainty. The same occurred with the asset specificity attribute. It seems the specialization generated in labor, result of the increase in TIS dynamicity, does not tie it to a given transaction of a specific alliance, and it may be reallocated to other transactions. The data found show that the structural relations proposed correspond to the theoretically proposed effect, even when not attending to the minimum parameters of statistical significance.

A methodological contribution of the study is that this paper proposed a set of indicators for the quantitative characterization of the Technological Innovation System construct. As far as the authors know, these constructs have been operated based on qualitative data as proposed by Carlsson; Stanckiewicz (1995).

The study results provide implications for administrative practice in the sense that it helps in strategic decision-making for location. The proposed theory suggests that strategic decisions of location for biotechnology companies prioritize developed, structured and dynamic technological innovation systems. These results corroborate Powell; Packalen; Whittington (2012), when they affirm that a cohesive institutional field between players and the presence of an anchor company in the industry are key factors for the emergence of blocks of development responsible for the economic growth of companies or groups of companies.

The limitation of this study is in the exploratory character of the study. Studies that operationalize the relationships between Dynamicity of TIS and Transaction Attributes constructs were not found. The structural model presented may not be valid for other industries. Thus, the results found should be analyzed with caution by company managers in this industry.

Future studies should evaluate three possibilities of replication of the proposed and tested model, which are: (1) increase the number of companies in the sample, (2) work with secondary data from other regions and (3) better explore issues tied to the nature of transaction uncertainty and asset specificity. The increase in the number of companies tends to reinforce, and even improve, the value obtained by the relationship significance test, since it is known that tests are influenced by the sample size used, principally as a result of the high number of variables of the proposed model.

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