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The Performance of the Technology Transfer's Office of Ceará in Light of the Effectiveness of Its Technology Transfer Processes

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Abstract Considering relations between universities and productive sector, the Technology Transfer Offices (TTOs) play a fundamental role in fostering innovation and in the process of technology transfer (TT), since they are responsible for studies of technological prospecting and competitive intelligence and their protection in the field of intellectual property (IP). The present study has the objective of identifying the effectiveness of TT processes as a measure for the performance of Ceará's Science and Technology Institutions (STIs) TTOs in the light of the analysis of their technology, innovation promotion policies and intellectual property protection. It regards qualitative, exploratory-descriptive research, with a multiple case study method. The data collection was done through documentary research and semi-structured interviews with three groups of actors who have already participated in TT processes: researchers, TTO managers, and company managers. Through the triangulation of data, the results show that these institutions do not yet have adequate adherence to the models of business innovation management used by the local productive sector and lack bidirectional planning. Despite the advancement of the scope and quality of services offered by TTOs and the amounts of technology contracts, there has been an extensive effort to improve the communication channels and to promote innovation. With the identification of factors that contribute to and hamper the promotion of change in the Ceará' scenario, the characteristics that group STIs in different stages of maturation were detected.

Keywords: Performance. Technology Transfer. Intellectual Property.

1. Introduction

The relationship between universities and companies (U-C) has amplified higher partnerships in between government, university and industry to increase the indexes of generation

and transfer of scientific knowledge (Baldini, Borgonhoni, 2007). The university began to assume an increasingly important role in the socioeconomic context, contributing with technological changes that can positively affect the richness of the nations (Dagnino, 2008; Kenney; Mowery, 2014; Gimenez; Bonacelli, 2013).

Need to highlight the triple-helix model proposed by Etzkowitz and Leydesdorff (2000), as one of the most referenced ones for the different agents of the process of generation, diffusion of knowledge, innovation, and transfer of technologies necessary for the development of society where the government has a fundamental role as a catalyst (Closs; Ferreira, 2012).

In the academic revolutions context and the constant need to adapt universities and research centers, the social mission of the Science and Technology Institutions (STIs) began to cover physical and intangible elements in the economic, legal and ethical fields of their strategies. A higher goal to generate benefits for society and strengthen institutional commitment through policies and activities that positively affect the internal public, community, and all stakeholders.

In the face of the U-C relationship, the Technology Transfer Offices (TTOs) play a crucial role in fostering innovation and in the process of technology transfer (TT), since they are responsible for technological prospecting and competitive intelligence and their protection in the field of intellectual property (IP). Brazilian TTOs models still have inefficiencies to be solved, and their processes are not entirely replicable (Dias; Porto, 2013).

At the same time, the TT process becomes necessary for the industry to make advances in industrialization and competitiveness. To Philbin (2008) and Malik et al. (2011) cooperation could provide knowledge improvements and academic experiences, by following the quick technologies' changes and integrating new products into their portfolios. On the other hand, universities could access to different funding sources and a better understanding of current strategies and future ideas of companies.

According to Torkomian (2009), only 18% of Brazilian TTOs are located in the Northeast region, mostly linked to universities and with lots of problems to be. In an attempt to overcome obstacles, TTOs tend to group in networks to be more effective in their actions. Since 2010, Ceará' TTOs, have been grouped on REDENIT, which has made significant advances in the state's innovation scenario, as well as stimulating the emergence of new TTOs, helping to structure and strengthen it through the foment of good practices in partnership with stakeholders (Silva, 2016).

Regarding the maturity level pointed by Silva (2016), only 20% of Ceará' TTOs present high development referring to structural and institutional aspects. Among the various bottlenecks, the lack of actions' effectiveness, characterized by the absence of administrative and financial autonomy and the lack of institutional regulation by STIs, reflecting the breadth of her activities and decision-making process.

The question is: how effective are technology transfer mechanisms for the promotion of innovation, protection of intellectual property and the increase of technology contracts of Ceará's STIs managed by their TTOs? And, what is the performance of Ceará TTOs in this TT' process?

The main objective is to identify the effectiveness of TT processes as a measure for the TTOs performance in light of the analysis of their technology contracts and IP promotion policies. To accomplish it, we seek to: recognize the characteristics of STIs by identifying their strategies for promoting innovation, IP and technology transfer; to verify the TTOs' performance in Ceará, comparing indicators of activities developed, objects of IP protection and technology contract' amounts; and characterize the strategies and mechanisms of TT and IP' effectiveness.

Is expected to contribute to the theoretical advance towards the model's construction for measuring TTOs performance considering the three main stakeholder groups involved' visions: TTOs and companies' managers and researchers.

2. Technology Transfer Offices and technology transfer process

On the primary sources of innovation by Vasconcelos (2002) pointed out the importance of technology acquisition through contracts between industries and universities, highlighting the fundamental role of research institutes to help companies to detect, select, negotiate and implement technological opportunities. Faced with the new universities' tasks, TTOs emerging to support technology management and strategies. Their essential roles are: to support the development of technological practices and marketing sites; to facilitate the market' introduction of new or improved technologies to optimize the production process, reducing costs and improving the quality and favoring the creation of new businesses with reduced risks provided by the technical and scientific opportunities coming from the universities. In this scenario, the role of TTOs is discussed in light of their collaborative tools for closer relations between U-C (Santos, 2008). For Siegel et al. (2003), the TT process usually follows essential internal rites where a researcher communicate a scientific discovery, TTO evaluates patenting viability and then, the patent can be requested from the National Institute of Intellectual Property - INPI. With the copyright in hand, the TTO should seek ways to license it. As the TT process depends to a great extent on the actual performance of the TTOs, they are expected to perform functions beyond those already predicted, promoting the creation of an environment conducive to TT and IP protection in their respective STIs (Santos; Toledo; Lotufo, 2009).

The speed with which TTOs were structured in Brazil, according to Costa (2013), ended up hampering their performance since, in many cases, there was not enough time for the elaboration of clear objectives, concrete and prioritization criteria, besides the already existing bureaucracy in universities and research institutes. In a relevant percentage of Brazilian TTOs, the structuring was commanded by professionals from other areas and without any action with the particularities of a TTO, creating a bottleneck between the needs of the organ and the qualification of the professionals that lead it.

Along the maturing path of TT processes, some barriers to cooperation between academia and the productive sector are verified, such as the lack of regulation of each STI, the length of project time and its degree of uncertainty, and the excess of bureaucracy in academic structures. Aware that it is of no use that the production of innovations by STIs if they do not leave their counterparts towards productive environments that can take them to the consumer market, the legal changes approved in 2016 promoted the increase of the minimum competencies of TTOs, so that these could, in fact, foster this migration of technology developed in STIs through transfer contracts.

Such contracts usually comprise (a) acquisition of knowledge through the provision of technology and provision of technical and scientific assistance services, (b) patent rights license or use of trademarks and (c) franchise agreements. At this point, the law also allows the TTO to act as a negotiator of STI in the mediation of intellectual property rights, through financial compensation or not, so that there is no harm to any of those involved (Marinho, Corrêa, 2016; Segatto- Mendes; Sbragia, 2002).

From this perspective, Table 1 shows the relationship between the main critical factors and challenges for TTOs related to TT.

Table 1 - Critical factors for technology transfer

ASPECTS	AUTHORS
<ul style="list-style-type: none"> - Institutional policies and norms; - Norms' institutionalization; - Established mission; - Legal model; - Management practices and identification of outstanding elements in the process of technology transfer; - Financial autonomy; - Networks development between researchers, entrepreneurs and technology managers; - University employees' high level of commitment to developing interaction; - The existence of technology transfer agents and offices (TTO); - Intellectual protection structure and organization; - Processes standardization; - Selection and qualification of technology managers capable of mediating relationships and playing critical roles; 	Santos; Toledo; Lotufo, 2009.
<ul style="list-style-type: none"> - Management skills; - Transfer modes; - The absorption capacity of the receiving company. 	Takahashi; Sacomano, 2009.
CHALLENGES	AUTHORS
<ul style="list-style-type: none"> - International Technology Protection; - Marketing of university technology; - Delayed internal procedures for universities; - Need to raise awareness in other sectors of the university; - Human resources management; 	Garnica, Torkomian, 2009.
<ul style="list-style-type: none"> - Bureaucracy; - Publicity of information by the university / TTOs/ companies; - Access to information; - Human resources management. 	Silva, Mazalli, 2011.

Source: prepared by the authors

Factors raised by the authors can be considered as fundamental premises for the existence and functioning of TTOs, according to the law that establishes them. Although they are necessary conditions of structuring, determinant for the success or failure of the market interaction and technology transfer efforts (Garnica; Torkomian, 2009; Santos; Toledo; Lotufo, 2009). Also, which in some measure determine the degree of maturity among TTOs, there are still challenges to be overcome even by TTOs considered mature.

An important aspect is the high turnover of professionals in TTOs, mainly due to the contracting model, based on temporary contracts or internships. The search for the establishment of these human resources fundamental for the continuity of actions has been done through hiring

by public tenders, in the cases of public STIs (Santos; Toledo; Lotufo, 2009). Other critical factors for the success of the negotiations are the identification of suitable business partners for the licensing of patents or the realization of joint R&D, communication and valuation of technology with reliable methodologies (Garnica; Torkomian, 2009). Without waiting to exhaust the challenges, but to list those more recurrent in the literature, it is still possible to highlight the slow pace of internal procedures and the need to sensitize other sectors of the university, which sometimes prevents the continuity of successful partnerships and transfers.

Based on the recognition by the government of the need to change some points in the innovation-related legislation to reduce bureaucracy and reduce legal obstacles and give greater flexibility to the actors of the National Innovation Systems (NIS) in January 2016 Law 13.243 / 2016, known as the new legal framework for innovation or a unique code for science, technology and innovation, was enacted.

The new legal framework focuses on strengthening national research and production, particularly the promotion of supportive environments for scientific, technological and innovative products in the country. A great deal of attention has been given to the establishment of mechanisms that can encourage and give greater legal certainty to the interaction between STIs, productive sector and the agents that intermediate this relationship: support institutions and TTOs (Rauen, 2016).

Among the changes proposed in the new code are: minimization of barriers to the importation of inputs to be used in R&D, formalization of far-reaching innovation stimulus grants, formalization of private STIs and expansion of TTOs functions, including the possibility of supporting foundations play this role (Rauen, 2016; Marinho, Corrêa, 2016). Among the changes with the most significant impact are: change in the concept of STI, the possibility of sharing and permission to use its facilities, the provision of technological services, partnerships agreements in innovative activities, resources to cover operational expenses and in the attributions of TTOs.

The new legislation added the figure of private STI, a private non-profit legal entity, disciplined the counterparts of public STIs, extended the possibility of sharing and permission to use public STI facilities for financial or non-financial colleagues. Formalized the feasibility of financial contributions from support foundations, did not restrict sharing only to micro and small businesses and added individuals, extended the incubation for other STIs as well, in addition to the companies already planned. It also inserted the concept of intellectual capital among the permits for innovation projects and maintained the requirement of equal opportunities for companies and institutions interested in sharing public STIs (Rauen, 2016).

The main change in the provision of technological services is the type of service rendered, which becomes technical-specialized and the formalization of financial counterparts through support foundations. In the comparison of partnership agreements in innovative activities, there was the inclusion of services that gave students the possibility of participating in innovation projects and gave the STI perspective to assign the intellectual property rights to the partners (Rauen, 2016;). On the TTOs theme, the new framework allowed them to have their legal personality and that these could be taken over by foundations of support, conferred new powers and empowered its manager to represent the public STI in subjects related to its policy of innovation (Marinho, Corrêa, 2016).

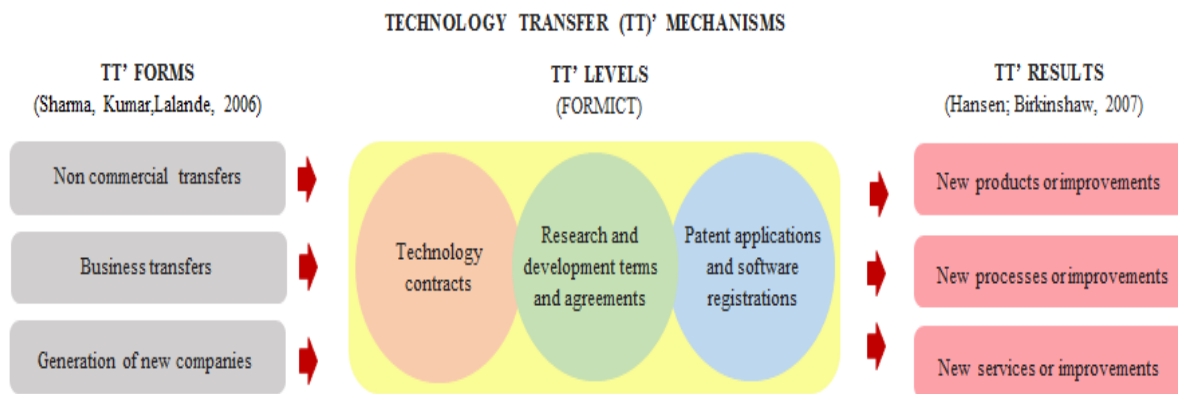
Law 13.243 / 2016 brought significant changes that consisted in optimizing the process of technology management and transfer, as well as intellectual property, now with an expanded concept and with the elaboration and negotiation of technology contracts exercised by TTOs. The

products with potential for innovation developed through partnerships also started to have differentiated treatment of consumer goods already consolidated in the market (Marinho, Corrêa, 2016).

Finally, knowing that the purpose of the productive sector is profit; it is imperative that ICTs develop technological prospecting and competitive intelligence efforts so that technology research and transfer contracts will be of benefit to both parties and that the results generated will serve their social mission and serve the best to the interests of society (Marinho, Corrêa, 2016).

The effectiveness of NITs is taken as a necessary measure of evaluation and is understood as their contribution to academic, economic and social development through the continuous implementation of mechanisms to promote innovation and technology transfer - TT of the institutions to which they are linked. A study model based on the criteria enumerated by FORMICT, the forms of TT proposed by Sharma, Kumar, and Lalande (2006) and the TT results postulated by Hansen and Birkinshaw (2007) is recommended, as shown by the figure 1.

Figure 1 - Study framework - Effectiveness of TTOs performance
STIs' PERFORMANCE LINKED TO THEIR TTOs EFFECTIVENESS



Source: prepared by the authors

3. Methodology

This study is classified as exploratory-descriptive research, with a qualitative approach and a multiple case study was carried out. The study objects were the 19 TTOs constituted in the STIs of the state of Ceará, in different levels of maturity (Silva, 2009), that had already made some effort of TT, besides the companies that had participated in the process of transference and the researchers-inventors of technologies.

Of the NITs in the state, 12 responded to the latest edition of the Form for information on the intellectual property policy of the Scientific and Technological Institutions of Brazil (FORMICT). Thus, the delimitation of the sample was determined by the survey of how many of the twelve NITs located in Ceará answered the last edition of FORMICT and attempted to do some formally established technology transfer process.

For the data collection, the sources of evidence of data highlighted by Yin (2005, p. 74) were considered: "documentation and records in archives, interviews, direct observations, participant observation, physical artifacts, and photographs." As for documentation and records in archives, the questionnaires answered annually by the TTOs and compiled by FORMICT. Copies of non-secretive technology transfer and research contracts were analyzed to describe the

strategies of the institutions for innovation and to provide subsidies for to observe possible changes in their policies and the progress of the activities developed by TTOs.

Sixteen semi-structured interviews were also carried out, totaling approximately 22 hours of meetings: 5 researchers (R), 7 TTO' managers (TM) and four companies' managers (CM) mapping. Through the triangulation of data among the researched stakeholders, the institutional practices and their perceptions about the changes resulting from the new legislation, as well as to detect if these changes interfered in the companies' final result and the performance of the institutions.

Table 2 - Summary of the volume of data analyzed.

INSTITUTION	FORMICT	INTERVIEWS		
		TTO' MANAGERS	COMPANIES' MANAGERS	RESEARCHERS
CENTEC	3	0	0	0
EMBRAPA	0	1	0	2
IFCE	3	1	0	0
INSTITUTO ATLÂNTICO	2	1	0	0
NUTEC	3	2	1	1
PADETEC	0	1	0	0
SENAI-CE	1	0	0	0
UECE	3	1	2	1
UFC	0	0	1	1
UNIFOR	2	0	0	0
UNILAB		Unable to evaluate - Very recent TTOs		
URCA		Unable to evaluate - Very recent TTOs		
INTA		Unable to evaluate - no response		
UVA		Unable to evaluate - no response		

Source: prepared by the authors

The analysis is structured into categories related to the three groups of respondents, namely: Regarding TTO, it is intended to understand: i. Institutionalization and operation of the TTO, which includes the existence of a policy or similar that establishes the management of the intellectual property of the institution and its norms, legal model, financial autonomy, human resources; ii. Processes, which include the organization of the structure of protection and transfer of technology, standardization of processes, management practices, marketing; iii. Collaborations with: (a) productive sector, as established partnerships, collaboration strategies among researchers, entrepreneurs and technology managers, perception of difficulty factors and stimulus to TT; the ability of companies to absorb technology; cooperation with external institutions and inherent expectations; (b) inventors, perception issues regarding access to TTO, support received in IP and TT protection processes. Part of this can be found in Silva's (2016) research, however, not addressing the TT process, which is the shortcoming of the present study.

The analysis of the data was done through the technique of content analysis (Bardin, 2011) through three stages: pre-analysis, analysis and exploration, and interpretation. In the pre-analysis stage, transcripts of the interviews were organized into thematic content sheets for the investigation of the sense nucleus and subsequent recognition of agglomerations in themes. In the analysis and material exploration stage, we wanted to search for meaningful results by coding the lines organized in spreadsheets, sorting them and classifying them in: excerpts> central idea> category> theme.

Finally, we interpreted the data based on empirical materials and available theoretical references, seeking to establish relationships, verify contradictions and understand the phenomena of the research to find meaning in what the data treated revealed.

4. Results Analysis

Among the 10 STIs studied, three are private, and seven are public. Regarding the time of existence and functioning of their respective TTOs, 4 have 1 to 3 years of activity, and six have worked for more than three years.

How many of its managers in public STIs, most of them have been formally linked to the STI for more than ten years and hold the position of researcher or effective teacher as TTO manager for three years or more. In private STIs, their managers have a history of passages more than once by the institution, totaling a minimum of 6 total years in STI in diverse functions and, on average, two years in the position of TTO manager.

4.1 Strategies for promoting innovation and protecting intellectual property

Regarding the critical factors along with the technology transfer processes pointed out in the literature (Santos, Toledo; Lotufo, 2009; Takahashi; Sarcomano, 2009), all the interviewees highlights could be checked on Table 3:

Table 3 - Results per TTOs critical factors for technology transfer in Ceará

Results per TTOs critical factors for technology transfer in Ceará		
Santos; Toledo; Lotufo, 2009.	Institutional policies and standards	Only Embrapa, UECE and IFCE, have policies that are formally completed, disclosed and fully implemented. NUTEC is in the process of updating its IP policy and, at the moment, it is not disclosed on the site. The other STIs have only informal parameters, and some of them are in the process of elaborating their policies;
	Institutionalization of norms	Most STIs do not yet have norms and policies, 6 of them follow already institutionalized processes of TT and IP protection;
	Mission established	All the STIs surveyed have established missions, since the TTOs in specific, do not have a specific mission. There is a tacit understanding that the role of a TTO is to develop regulatory policies for IP, to market and promote TT;
	Legal model	All public STIs have a private legal sector, commonly called a prosecution, which deals with matters related to legislation that do not have the skills to work with issues directly related to IP. The common practice is the hiring of external offices that provide specific legal advice to TTOs. For most public STIs, the use of this external consultancy is carried out via REDENIT through notices so that affiliated STIs can request services such as writing patents, software registrations, and international deposits. Some of these STIs do not even have this type of aid yet. Only Embrapa claimed to have a legal sector for internal TT issues.

(to be continued)

Santos; Toledo; Lotufo, 2009.	Selection and qualification of TT managers capable of mediating relations and playing critical roles	Despite the fact that TMs have enough time to establish institutions, none of them judged themselves capable of valuing technologies and, in no small extent, also showed insecurity when negotiating assets of IP, and is limited to following the law nº 13.243 / 2016 art. 9th. The common practice among respondents is to allocate 1/3 for each party involved in the process of TT: STI, researcher, and company. All expressed discomfort to carry out these critical roles since they lack the training or market knowledge to carry out such negotiations or massive market approaches;
Santos; Toledo; Lotufo, 2009.	Management practices	<p>All TTOs implement to some extent many of the practices listed by FORMICT. Among the main ones are the follow up of orders and maintenance of IP titles.</p> <p>Regarding the maintenance of the institutional policy and incentive to IP protection, TTOs with more than three years of operation already provides standard contract models, terms for their researchers and partner companies, as well as promoting awareness of the internal body to the university regarding the importance of protection. About the dissemination of research results and creations developed within the framework of STI, there are different initiatives, such as newsletters, mailing list, and events of market approximation. STIs, in general, carry out some follow-up of the results of research projects and partnership agreements, although there is no specific index to classify the evolution of the projects, making it difficult to fully comply with timetables, in addition to the fact that a will necessarily produce a patent or software. Among the private STIs, all of them demonstrated the ability to receive demands from external researchers and inventors, and the free ones only the UECE. Most TTOs use events and capacities promoted by REDENIT to train and update their members.</p> <p>The relationship with the market is made preponderantly through the personal contacts of researchers and managers of TTOs. No STI has presented a database of possible companies that might be interested in their technologies. Contacts are often scarce and punctual, making it difficult to negotiate projects and IP assets;</p>
	Financial autonomy	No TTO, public or private, presented financial autonomy or outstanding budget. The only margin reported is the incentive linked to some research project that allows to make some purchase or contracting and, in the case of public STIs, linked to the law of bidding. Such limitations imposed by this law end up causing slowness to the processes of TT;
	Network development	A significant part of the TTOs are associated with REDENIT, adopt their practices and enjoy their network to benefit from the group's contact with the market to forge partnerships;
	High employee commitment	A common problem for all STIs revealed was the lack of staff of employees or employees effectively engaged and dedicated exclusively to TTO activities. The existence of scholars in this sector is dominant, causing the turnover rate to be quite high and knowledge is lost to each exchange of collaborators. The few STIs that manage to allocate employees are unable to do so in their entirety as these members accumulate functions;
	Existence of transfer agents	All STIs pointed to the existence of some sector or department with the main purpose of fostering innovation, TT and IP protection, some of them in the embryonic phase and some reported the existence of incubators and accelerators;
	Organization of the intellectual property structure	in some ways, each TTOs specialized in some specific area and, when within the same scope, try not to compete with each other. Such segmentations were never imposed nor formally instituted, emerged from the culture of each STI and the evolution of its expertise;
	Standardization of processes	Although NITs affirm that all its members would be able to carry out a cycle of technology transfer from start to finish, only Embrapa, UECE, UNIFOR and PADETEC presented structured and advertising processes;

Takahashi; Sacomano, 2009.	Management capacities	the most cited as basilar by the three groups studied were: technical knowledge, managerial practice, operational experience, and leadership capacity. All agreed that there is a long way to go by all actors involved in the process of maturity of approach and commitment among stakeholders;
	Modes of transfers	The most cited non-commercial transfers resulting from TT processes were scientific publications, participation in congresses and conferences, and networking expansion. For commercial assignments, collaborative research, technical services and consulting and licensing and sale of PI assets were mentioned, although few STIs in Ceará have reached this stage, and are still in R&D. In the generation of new companies, only UECE, Embrapa, IFCE, NUTEC, PADETEC, and UNIFOR were able to list spin-offs that reached the market;
	The absorption capacity of the company receiving the technology	It has been verified that there is a current attempt to approximate between STI x researcher x market for conversations and prior negotiations to formalize any R & D agreement precisely to avoid that the result from the academy is not in fully absorbed by the technology recipient.

Source: prepared by the authors

This research findings related to the critical factors coincide with the literature and point out the lack of definition of specific strategies to make the work of TTOs more efficient, often generated by the lack of human, technological and / or financial resources, causing the slowness of responses to the demands of the productive sector and the low TT rate (Santos *et al.*, 2009).

Regarding recent changes in the national innovation support legislation cited by Rauen (2016), none of the groups interviewed showed effective changes, the STIs did not finalize their internal regulations, and legal uncertainty remains. In the tangent of the possibility of sharing and allowing the use of laboratories, equipment and facilities of STIs with the market, both groups: CMs and TMs point to the current economic conditions of the country as a major inhibiting factor. Other difficulties for STIs, in fact, to feel changes deriving from the new legal framework were: the shortage of public promotion notices and the complexity of accountability on the part of companies that adopted the benefits of the Information Technology Law.

About the possibility of greater involvement and dedication of the researchers to the R&D, some of them attribute to the stagnation of their activities to the economic factors and the delay of the STIs to conform to the new milestone and to formally regulate. Pointing to some cultural aspects as a significant obstacle to the adoption of improvements such as the lack of information from colleagues about the need to broaden the university-company relationship and even oppose this movement, in line with the findings of Cruz, Cavalcante, and Reis (2015).

4.2 STI' performance and effectiveness of its TT mechanisms

Regarding the formal modes and means of TT adopted by Ceará' STIs, according to the interviews (TM2,3,4,6,7 and R1,2,4,5), there is a tendency and willingness to cooperate between STI. There has not been a significant increase in the total amount of technology contracts in the last three years. Specially after the enactment of the new legal framework for science and technology, it was not possible to perceive any difference and added the fact that accounts in situations that fall under incentives such as computer law, lack of experience in relation to STIs, and excessive bureaucracy and slowness of processes to initiate a collaborative R&D process.

Among the forms of TT pointed out by Sharma, Kumar, and Lalande (2006) and used in our study model, the noncommercial transfers pointed out in the interviews were publications,

informal contacts, and exchanges. Collaborative research and consulting and technical services were widely cited as cases of commercial assignments. As for the generation of new companies, six of the institutions claimed to have some relevant case of spin-offs, all of them have incubators. Of the 10 ICTs surveyed, only Embrapa has finalized the licensing and sale of IP assets with royalties.

Other forms of TT and business models were cited in the interviews and find space in other authors' models, such as Ades (2013): scientific cooperation with other STIs, scientific services without generation of patents, sharing of laboratories, covenants and co-creation, and, on the part of the companies, acquisitions of startups technologies, acquisition of startups and staggering of their techniques.

To clarify the differences between the maturation stages of the TTOs, the STIs studied were grouped by similarities in groups with different and compared characteristics. In Table 4 it is possible to verify in an illustrated way the stage of the TTO trajectory of Ceará, towards a later phase to be reached from an alignment of the current difficulties of Embrapa that results in a new aspect of maturation. In the fifth stage, the state has no institution yet.

Table 4 - Stages of the evolution of the Ceará' TTOs and their characteristics

INTERNSHIP I	INTERNSHIP II	INTERNSHIP III	INTERNSHIP IV	INTERNSHIP V
URCA UNILAB UFC	UNIFOR CENTEC SENAL-CE NUTEC INSTITUTO ATLÂNTICO	UECE IFCE PADETEC	EMBRAPA	Ø
* registered patents, trademarks and registered software;	* improvement of processes and internal flows related to IP and TT;	* scientific cooperation with other national STIs;	* scientific cooperation with national and international STIs;	* acquisitions of startup technologies;
* sharing of laboratories	* actions and events to disseminate STI' technologies;	* existence of co-creation and co-authoring of researchers with other STIs, external researchers or productive sector;	* the social impact of TT research and processes as infrastructure improvement, sustainability, education, and social interactions;	* startups' acquisitions;
* absence of patent generation services such as the search for prior art and writing of patents; only forward the patent filing application to the INPI;	* patent generation services: search of the prior art, writing of patents, filing of patents and registration of software and trademarks;	* good relationship with the public and productive private sector for the dissemination of their technologies and establishment of partnerships;	* consolidated teams and capacities formed mostly by capable STI members and with low turnover;	* staggering their technologies in progress;
* absence of contract models and delay in their elaboration and internal procedures;	* teams already trained already in training and training, although they still have high turnover and a high percentage of members with no direct employment relationship with STI;	* internal procedures and flows already regulated effectively implemented and widely disseminated;	* balance of publications and resources for TT and IP;	* good adherence to the business innovation management models used by the local productive sector;

(to be continued)

* technology transfer contracts in force;	* promotion of networking with actors of the local Innovation System;	* capacity to accommodate researchers outside STI;	* international patent filing;	* Expanded and consolidated distribution and communication channels;
* publications and patents already registered;	* higher speed in the conclusion of contracts and terms of the partnership due to the existence of pre-elaborated contract models;	* existence of incubation and acceleration environments;	* already enjoy a financial return from their TT processes, mostly royalties;	* technology valuation service already consolidated;
* interruption of research due to internal bureaucracy to STI;	* promotion to the general learning actions of its team and researchers;	* improvement in the management of contracts presenting some speed in the processes of protection to IP and TT;	* has its specific legal sector for matters related to IP and TT, and also has an external legal industry for the same purposes;	* existence of a person who negotiates STI technologies directly with the market, such as a broker;
* TTO in the implementation stage of operation for less than one year;	* good relationship with the local public sector and low involvement with the productive private sector;	* Teams already qualified but still with high turnover, some of its members presented direct employment relationship with STI;	* technology valuation service still incipient and done within the TTO itself with the help of the respective legal departments;	* speed of the processes of the conclusion of contracts, agreements and partnerships as quickly as possible;
* standards, regulations, and contracts being drafted;	* absence of specific legal department for matters related to IP and TT, the only general attorneys general of the STI;	* presents spin-offs as a result of TT processes;	* generates by-products from existing TT processes and new research;	* wide range of services that generate patents already implemented and easily accessible by internal and external researchers;
* reduced teams, in the process of formation, with high turnover and low number of competent members of the STIs;	***	* next start to get a financial return from your TT shares as royalties, stakes, and others;	***	***
* actions aimed at raising the awareness of its researchers about the importance of protecting IP;	***	* access to external legal advice for IP and TT protection purposes, as well as individual offices for general matters;	***	***

Source: prepared by the authors

In addition to the differences in stages, some difficulties are common to all STIs: challenges in consolidating and expanding their channels of communication and distribution and communication with the productive sector. Growing work teams and retaining their members avoiding turnover and loss of knowledge, improve internal processes and reduce bureaucracy to increase the speed of response to the market, more excellent understanding in assessing convenience and valuation of technologies, among others. These difficulties and challenges are addressed below.

4.3 Overview, Challenges and New Directions of Ceará NITs

By triangulating the data from the 16 interviews, it is possible to list opinions and feelings common to the three groups. The lack of human, technological and financial resources aside from the lack of autonomy and a specific budget for the sectors of technology transfer that, according to Santos et al. (2009) culminates in the absence of the use of local vocations and the poor management of intellectual capital. Another collective opinion is that there can be no deviation of the functions of TTO researchers and managers since they need time, maturity and training to understand and dedicate themselves to the entire TT process and allocate them partially. For Stern, El-Ansary, and Coughlan (1996), this deviation from function means loss of knowledge.

As a challenge to improve the services, relationships and results offered and demanded by the three main actors of the system; it is necessary that the communication and marketing areas of the institutions usually focused on the government, focus on the client. For Rush et al. (1996), it is necessary to identify and meet the technological needs of the market by establishing processes that help STIs to understand the support needs of their stakeholders and connect them to the capacity of generating STI technologies, identifying and managing potential customers and buyers to the academy offers.

Garnica and Torkomian proposed some challenges for TTOs in 2009 and these remain current for the economic scenario of Ceará. There is still a need to move towards reducing delays in the internal processing of STIs, raising the awareness of other sectors of STIs to the importance of involving all stakeholders in the TT process and their importance to the length of their mission. For some surveyed, it is necessary to end the idea that the researcher is a usurper of the university assets because he is transferring academic knowledge to the market. The results of the TT mechanisms should be informed to all possible stakeholders so that the TTO can promote a continuous, reliable and prolonged approach with the productive sector and for its internal public to have access to the information.

Is essential to note some TTOs and companies' managers and companies, in the absence of a person qualified within the STI to market the results of R&D and IP, and the impossibility of hiring one. It is poignant to look for the figure of a broker to proceed with the commercialization of technologies so that these are not just waiting for a future and distant moment of marketing.

Final considerations

The present study aimed to identify the effectiveness of the technology transfer processes as a measure for the performance of the Technological Innovation Centers of the Science and Technology Institutions of the state of Ceará in light of their technology contracts and policies to promote the intellectual property. It is believed that this objective was reached, once it was perceived that the institutions of Ceará are, to a certain extent, moving towards the maturation of their mechanisms of technology transfer, protection of intellectual property and promotion of innovation.

About the characteristics of STIs and their policies to promote innovation, intellectual property, and technology transfer, it was found that, in general, these institutions still do not have adequate adherence to the business innovation management models used by the local productive sector. They are suggesting the detailing and adequacy of stakeholders, management of conflict points and expansion of communication channels not contemplated in current practices. There are

different views among the actors that participate and influence the relations between STIs and companies and that even conflict between researchers and managers of the same institution.

It is necessary that the actors involved in the various forms and processes of TT are considered as tools for generating value where the benefits offered by each part are taken into account in the negotiation processes with a view to collaboration and exchange of results.

Regarding the performance of the TTOs of Ceará, comparing the indicators of activities developed, objects of intellectual property protection and amounts of technology contracts, it was possible to verify the progress of the coverage of the services offered by TTOs, the quality of the services provided to its external public and contracts and the amounts of technology contracts.

Regarding the effectiveness of the strategies and mechanisms for transferring technology and intellectual property of STIs in the state of Ceará, there is a general effort to promote innovation in all economies, a factor that affects the conception of competitiveness among STIs and requires faster negotiations with the productive sector and in the deposits of patents and software registries. To reach results a shared business vision between STIs and companies is necessary so that the commercial relations and the formation of strategic alliances can be advanced as a consequence of shared experience and mutual trust between the parties.

According to the data collected in the research, the structuring and implementation of TTOs did not generate a perception of improvement in the relationship between STIs and productive sector according to the managers of companies. On the other hand, the vision and the different interests among the groups surveyed pointed to the need for higher training among TTO professionals and managers within the STIs, as well as the reduction of bureaucracies and the adoption of multivariate strategies to approach academia and the market. The existence of culture and infrastructure with technical teams enabled to promote interlocution with researchers and the transfer of technology, both in the institutions and in the market, were aspects considered as more impacting for the efficiency of the TT processes than the formalization of the structure of the TTOs.

The adoption of TT mechanisms in Ceará's panorama still lacks two-way planning so that companies can demand products, services, and processes and that STIs can be able to offer, in time, business possibilities. To do so, the improvement of the communication channels was a recurrent aspect in the speeches between all groups and indicated as a viable way to counteract the demand and supply of knowledge, to ensure the progress of the processes and to generate joint solutions to impede the relationships between the actors. Understanding the motivation of researchers to innovate and create new ways of recognizing success in transactions appeared in the discourses as suggestions to promote the awareness and greater adherence of the STI staff to the TT processes.

It is possible that the highest theoretical contribution of this study has been the triangulation of data, visions, and aspirations of the different actors and interested in the effectiveness of TT mechanisms, besides the identification of factors that contribute to and hamper the promotion of innovation in the Ceará scenario. As suggestions for future studies, the research could be replicated in similar situations in other states or countries for the purpose of comparison and creation of models and communication channels capable of detailing aggregated values by a higher number of stakeholders such as: government and society, besides the already studied: researchers, industries and managers of TTOs. Another suggestion would be the creation and validation of a system of new metrics to evaluate the performance of TTOs and researchers in addition to those already used by FORMICT, as well as the creation of indicators that can determine the capacity to innovate specific to STIs.

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