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Original Article

Performance of Technology Transfer Offices (TTOs) in the Technology Transfer Process of the Technology Innovation Centers (ISTs) in Brazil between 2007 and 2017

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Abstract: *The analysis of the performance of Technology Transfer Offices (TTOs) in the technology transfer process of Brazil's Technology Innovation Centers (ISTs) between 2007 and 2017 is the focus of this article. The research is applied in nature, employing a quantitative approach with descriptive-exploratory objectives. It utilized data from the Form Reports on the Intellectual Property Policy of Scientific and Technological Institutions in Brazil (FORMICT). The technical procedures used were bibliographic and documentary. It was observed that there has been a significant increase in the number of TTOs implemented, but there is a need for more advisory services. The findings corroborate the good performance of TTOs over the years in implementing innovation policy but highlight the necessity to expand actions and strategies to promote innovation. In the general panorama of technology transfer actions, the data showed that during the years analyzed, Brazilian ISTs signed a considerable number of technology transfer contracts, although the number of ISTs signing them is still small.*

Keywords: *Technology Innovation Center, Technology Transfer Offices, Innovation.*

I. INTRODUCTION

Technological innovation management is a unique, complex type of managementthat must interact with a wide variety of agents in the innovation process (SARTORI, SPINOSA, and NOGAS, 2017). It is, therefore, up to the Technology Transfer Offices (TTOs) to carry out their activities in such a way as to create an atmosphere that is conducive to the transmission of technology. In this sense, Technology Transfer (TT) is one of the ways in which the knowledgegenerated by ISTs can reach companies and, consequently, drive innovation. Technology transfer has been highlighted as a challenging task for many institutions (HOSSAIN, 2012; COHEN, 2004). The challenges that surround Institutions of Science and Technology (IST) in relation to the TT process involve the construction of market procedures (marketing), the valuation of patents, negotiation and appropriate licensing (contracts) (HORA, 2020).

TT from research to industry is not a simple process; it is considered one of themain bottlenecks when it comes to innovation, and there is a need for reciprocal exchangebetween the partners. It is through this legal transaction that the rights to certaintechnology, knowledge and other intangible assets are transferred, and in this way, thepartners make use of this technology (FREY et al., 2019; AGUSTINHO, GARCIA, 2018). One of the advantages of IST-industry interaction for the external acquisition ofnew products, processes or technologies through TT is that companies do not have to take part in the costly and hazardous early phases of research and development; the institutions share expenses and risks in this way (HUNG, 2008).

On the other hand, what has been observed is that IST-industry interaction is stillat an incipient stage, and the TTO's work is focused on protecting intellectual property, with a restricted view of the university-industry relationship (PARANHO *et al.* 2018). The profile of the current TTOs is classified as merely administrative, acting onlyas an interface to process Intellectual Property (IP) referrals and carry out actions of an exclusively operational nature (COELHO and DIAS, 2016).

In this context, the research seeks to show the performance of TTOs in the interaction and cooperation between ISTs and companies since TTOs are understood to be sectors responsible for generating innovation and entrepreneurship policies, and if theiractivities are well managed, they can become a reference in actions aimed at technologytransfer. In this way, we intend to answer the following question: what is the performanceof Brazil's TTOs in the technology transfer process to promote IST-industry interaction? Given this problem, this article aimed to analyze the performance of TTOsin the technology transfer process between 2007 and 2017.

Apart from this introduction, the essay is divided into six sections. Sections two and three present a brief review of the literature on Technology Transfer for innovation in Institutions of Science and Technology. The fourth section describes the methodology used to gather data and information on innovation policy and the evolution of TTOs over time. Data analysis, results and discussions are presented in the fifth section. Finally, the sixth section highlights the main conclusions of the work and some points for a future research agenda.

II. TECHNOLOGY TRANSFER FOR INNOVATION

The technology transfer process usually involves moving a technological innovation from a Research and Development (R&D) organization to a receiving organization (for example, a private industry). The technology transfer process covers the stages from R&D to commercialization and beyond but with a particular focus on the interface between R&D (usually by a university research center, a corporate unit or a government laboratory) and commercialization (usually carried out by private industry). Thus, technology transfer is a special type of communication process (ROGERS, YIN, 2000; DESIDÉRIO and ZILBER, 2015).

TT is a process of transferring scientific discoveries from one organization to another for the purpose of development and commercialization, and universities and research institutions are fertile ground for inventions, but having an idea, even a revolutionary one (AUTM, 2020; LIMA, JR., 2021; AMRY, AHMAD, LU, 2021). TT is defined as a two-way communication process whereby two parties (the provider and the receiver) exchange knowledge, and the acquisition, understanding, absorption and application of technology or a technological process by the receiver takes place objectively and successfully. TT is considered an agile mechanism in the innovation process that seeks interaction between the generator and the party interested in absorbing the technology (BURLEM, 1977; ULRICH, FIGUEIREDO, MACIEL, 2020).

The TT process requires minimum conditions to be met: the transferor needs to be willing to transfer, and the recipient needs to be able to absorb the transferred technology and knowledge. This means that TT involves building a partnership between technology providers and technology seekers (DIAS and PORTO, 2014). In a systematic review of technology transfer generated in university-industry collaboration, Arena and Gonzales (2018) identify the common elements used in a general model of technology transfer. The message, the medium and mechanism, the transmitter, and the receiver are these. The physical form of the item to be transferred, like a patent or prototype, is referred to as the medium and the means by which it will be presented—such as through licensing, contracts for sales, expertise, spin-offs, and other means—is referred to as the mechanism itself.

Other TT mechanisms relating to the sharing or use of physical laboratory infrastructure, intellectual capital or public spaces for the construction of innovation-promoting environments, such as incubators and technology parks, also contribute to encouraging the Technology Transfer that a Technology Innovation Center can perform. Dias and Porto (2014) point out that technology transfer offices (TTOs) are becoming increasingly dynamic within the academic structure and their contribution is reflected in the growth in the transfer of technologies developed within universities. They are actors that have real possibilities of materializing public cooperation and TT policies in the various spheres of government.

The TT activities carried out at universities are increasingly considered to be an important source of regional economic development and a revenue opportunity for the university (FRIDMAN, SILBERMAN, 2003; TOCACH, 2011). Moreover, from the companies' point of view, the motivations for cooperation lie in being able to rely on university training to develop technology, reducing research costs, access to the university structure and highly qualified labor (SEGATTO-MENDES; MENDES, 2006; SILVA, 2007; BOTELHO; CARRIJO; KAMASAKI, 2007). One of the main stages of the technology transfer process is the valuation of intangible assets, as this is where the terms of the inventor's remuneration and the respective values are defined, as well as the design of the most suitable transfer conditions to offer to potentially interested parties.

III. INSTITUTIONS OF SCIENCE AND TECHNOLOGY (IST)

Innovation in Brazil was encouraged by Law 10.973/2004, which, among other resolutions, institutionalized TTOs for the purpose of managing the innovation policy of ISTs (BRASIL, 2004). TTOs play a strategic role that goes beyond a mere intellectual property office, and some functions should be taken into account and should not just respond to a legal requirement (PIRES, SANTA RITA, and PIRES, 2020; PIRES and QUINTELLA, 2015).

Law 13.243 was passed in 2016 with partial vetoes. It is considered the new legalframework for science, technology and innovation in the country, as it brings advances toinnovation in Brazil, especially when compared to the 2004 law. The law expands the attributions of TTOs, which makes them strategic and allows them to take the form of support foundations, as well as making it easier to share IST laboratories and formalize private ISTs, among other new features. In this way, the results of the research carried out at ISTs will actually benefit society (GOMES DE CARVALHO; TONELLI, 2020)**.**

Therefore, according to the current legal framework, TTOs must carry out their activities internally, externally and protectively. Internal activities include registering processes, managing the activities carried out and generating analytical

reports. External activities include interaction with the government and the productive sector, as well as other interactions, such as with the internal and external community, incubators, research support foundations, *startups*, *spin-offs*, technology parks and other agents that make up the innovation ecosystem. The activities linked to protection refer tothe registration, monitoring and evaluation of processes involving the management of intellectual property, licensing or technology transfer contracts, co-ownership contracts, technical cooperation terms, secrecy terms, consultancy and other duties involving the protection and transfer of knowledge generated within the IST (COELHO and DIAS, 2016; GARCIA, BISNETO and SANTOS, 2017; IATA *et al*., 2017),

Ferreira and Teixeira (2016) emphasize that the TTOS are the mediators of knowledge transmission, so they should boost innovation and entrepreneurship in ISTs, which involves drawing up studies and strategies for the transfer of innovation generated at the IST, technological prospecting studies, enabling and maintaining the IST's relationship with companies, negotiating and managing technology transfer agreements originating from the IST.

When analyzing the management practices carried out in various technological innovation centers, it was observed that the TTOs still need to develop their competencies through a definition of organizational processes that highlight the importance of points related to the promotion of technological innovation resulting from the efforts of scientific research and technological development of the IST (ANDRADE and CHAGAS, 2018).

In this sense, it is possible to observe that TTOs are important diffusers of technology since they promote a closer relationship between the university and the entrepreneurial world, stimulating activities related to research, development and innovation and the management of technologies created within the university (FULLER; PICKERNELL, 2018).

In the international literature, TTOs are similar to Technology Transfer Offices (TTOs) (SOARES, TORKOMIAN, NAGANO, & MOREIRA, 2016), which are organizations that specialize in transferring technology or knowledge from ISTs and whose central mission is to increase the chances that discoveries from universities and research institutes will be converted into products and services that society can benefit from (CAPART and SANDELIN, 2004). They are gap fillers and intermediaries between universities and industry in the commercialization process.

IV. METHODOLOGY

It is of an applied nature, with a quantitative approach and descriptive-exploratoryobjectives. For the quantitative approach, we used data from the Form Reports on the Intellectual Property Policy of Scientific and Technological Institutions in Brazil (FORMICT) from the base years 2007 to 2017. The FORMICT report is produced by theMinistry of Science, Technology, Innovation and Communication (MCTIC) and aims topresent and monitor the Intellectual Property Policy of Brazil's Scientific, Technologicaland Innovation Institutions. The electronic form, available at www.mct.gov.br/FORMICT, must be filled out annually by the ISTs as required by Law 10.973 of December 2, 2004(Innovation Law, amended by Law 13.243 of 2016), which establishes in article 17 that public ISTs and private ISTs benefiting from public power must send annual informationto the MCTIC.

The technical procedures used were bibliographic and documentary. According to GIL (2010), bibliographical research and documentary research have similar pointsand can be confused. The author points out that the main difference between the two is the nature of the sources researched. Bibliographical research is based on material preparedby authors with a specific purpose to be read by specific audiences. Documentary research, on the other hand, makes use of all sorts of documents drawn up for various purposes, such as settlements, authorizations, communications, etc.

A survey was carried out in the databases of the main academic research tools, CAPES Periodicals Portal, Scielo, Google Scholar, and Science Direct, by searching for scientific articles related to the topic of technology transfer and TTOs using an advanced search strategy, considering the fields: "title", "abstract" and "keywords".

The collection of secondary data on intellectual property, technology transfer for innovation and TTOs, in order to substantiate the research, contributed to deepening the objective of this work and took place between April and July 2022. The study of secondary data allowed us to verify new realities about innovation policy and theevolution of TTOs over time. Other associated doctrinal works considered to be references on the subject of TTOand TT were evaluated, with the aim of gathering, analyzing and interpreting relevant information that would provide greater clarification and understanding of the concepts. Legislation on the subject was also consulted, in particular the CT&I Legal Framework - Law No. 10.973/2004, Law No. 13.243/2016, and Decree No. 9.283/2018.

V. DATA ANALYSIS OR RESULTS AND DISCUSSIONS

With regard to the stage of implementation of TTOs (implemented, under implementation or not implemented), the data consolidated in the FORMICT reports from 2007 to 2017 showed that the implementation of TTOs is not yet consolidated in all

institutions, but it can be seen that there has been a significant increase in implementation in recent years, which has probably had an impact on the number of intellectual properties generated at ISTs, according to Table 1.

The implementation and consolidation of the centers are still pointed out as challenges in Brazil (KATZ et al., 2017; TOLEDO, 2009). According to Bortolini et al. (2014), given that many TTOs were only "built" as a result of the obligation laid down in the Innovation Law, the process of providing advice, whether in terms of training human resources, helping to obtain resources and so on, is extremely important for the successful development of institutions. According to the authors' survey of 63 TTOs across Brazil, approximately half of the respondents said they had not received any advice during the process of implementing/managing their activities. In this sense, there is a need to create a plan to help structure TTOs, generating greater possibilities for sustained development.

With regard to the implementation of the innovation policy, it can be seen in Table 2 that there has been an increase in the number of institutions reporting that they have formal documents with guidelines that guide the institution's actions related to innovation, protection and technology transfer. The fact that the vast majority have made progress on this item already demonstrates the important role played by TTOs in these ISTs, which have been responsible for managing innovation policies in ISTs since 2004.

Table1: Implementation of TTOs.

	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Participants	72	101	156	164	176	193	261	264	268	278	297
Implemented	54	75	80	94	116	141	166	180	199	208	226
Being Implemented	15	6	59	60	49	39	66	54	48	46	37
Not Implemented	3	20	17	10	11	13	29	30	21	24	34

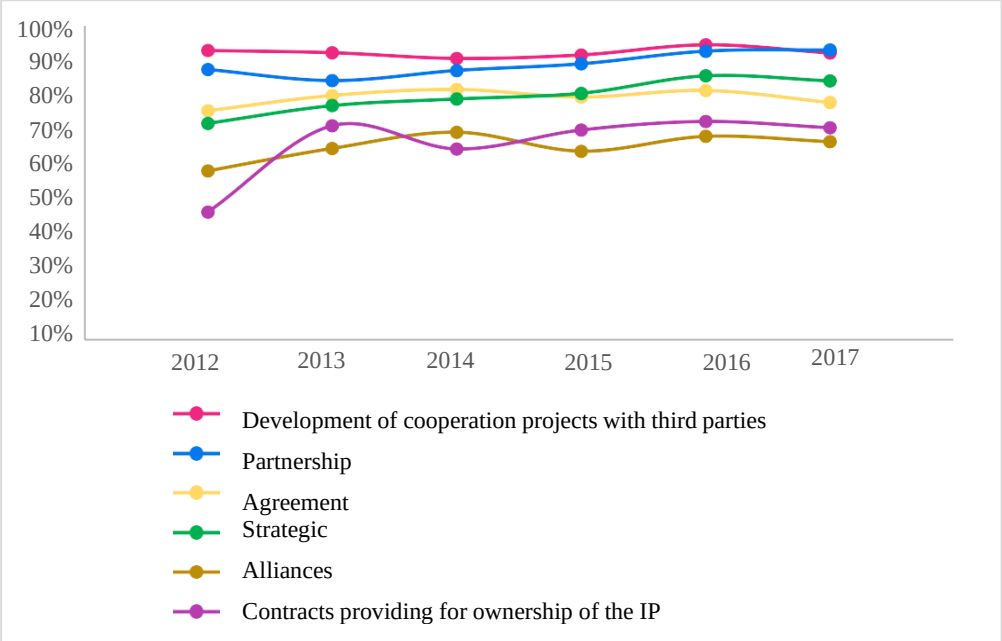
Table 2: Implementation of innovation policy.

	2007	**2007**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
TTO Implemented	-	-	80	94	116	141	166	180	199	208	226
Innovation Policy Implemented	-	-	113	107	126	133	181	194	204	192	212
Innovation Policy not implemented	-	-	43	57	50	60	80	70	64	86	85

In contrast, according to research carried out by Almeida and Pinheiro (2020) on the development of innovation policy at federal universities in the Northeast in 2020, through the Innovation Law, addressing the process of institutionalization of TTOs, it was possible to demonstrate a growing mobilization of institutions in the implementation of structures related to innovation provided for in legal instruments, but with still limited performance regarding patent registration, according to INPI regulations. Despite being in place, the TTOs reveal initiatives that are still incipient in terms of promoting innovation.

Figure 1 shows the activities associated with innovation policy among institutions that have reported having such policies in place, with specific emphasis on certain activities. However, it should be noted that FORMIST did not provide data prior to 2010.

Figure 1: Percentage of implementation related to interaction with third parties



In terms of activities related to innovation policy, for the institutions that reported having an innovation policy in place, the data shows that certain activities with a higher incidence in the ISTs' innovation policy stand out: development of cooperation projects with third parties, partnership agreements and strategic alliances, which are present in all the years, always above 70% of the cases. The activities of transfer and licensing contracts and contracts providing for ownership of IP and participation in results have gained importance over the years, with an increase in incidence in a greater number of ISTs, rising from 54% to 63% and from 69 % to 82 %, respectively. It can be seen; however, that little has changed in terms of the frequency pattern of activities mentioned in ISTs' innovation policies, except for the activity of sharing facilities, which saw a sharp increase in 2011.

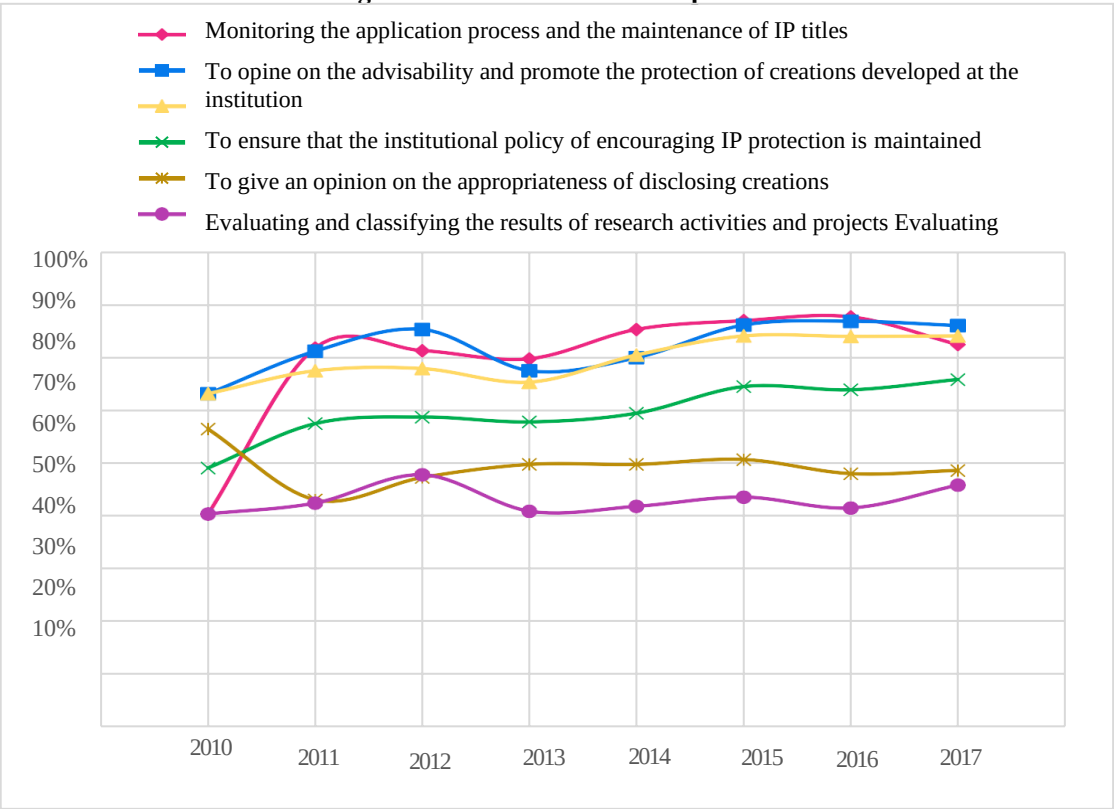
In the studies carried out by Monosso et al. (2019) in the southern region of Brazil, it was possible to identify strategies adopted by institutions to promote innovation related to interaction with third parties. The most cited innovation policy objective refers to the management of intellectual property and technology transfer, which includes licensing, management of assignment contracts, know-how and the selection of strong products for patents, which are developed within the internal community.

With regard to the development of partnerships, the study highlights that 90% of ISTs have already consolidated partnerships with companies through contracts. The most common types of contracts are related to the licensing of intellectual property rights (72%), confidentiality and ownership agreements (64%) and partnership agreements for the development of RD&I (55%).

In accordance with the sole paragraph of art. 16 of the Innovation Law, the activities carried out at the TTO have been separated into two subgroups: essential and complementary, Technology Transfer and other forms of interaction with the productive sector.

In the historical series between 2010 and 2017 (Figure 2) on essential activities, it can be seen that those that touch on relations with third parties are the least implemented: "Evaluating requests from independent inventors for the adoption of inventions" and "Evaluating and classifying the results arising from research activities and projects". Moreover, of these, the ones with the highest implementation rates were: "Monitoring the processing of applications and the maintenance of IP titles", "Opining on the suitability and promoting the protection of creations developed at the institution", and "Ensuring the maintenance of the institutional policy to encourage IP protection". With this, it can be said that the main activity of the TTOs is intellectual property, given that from 2011 to 2017, more than 70% of the TTOs carried out activities related to it. Certainly, there must be TTOs that only carry out actions pertaining to property rights protection.

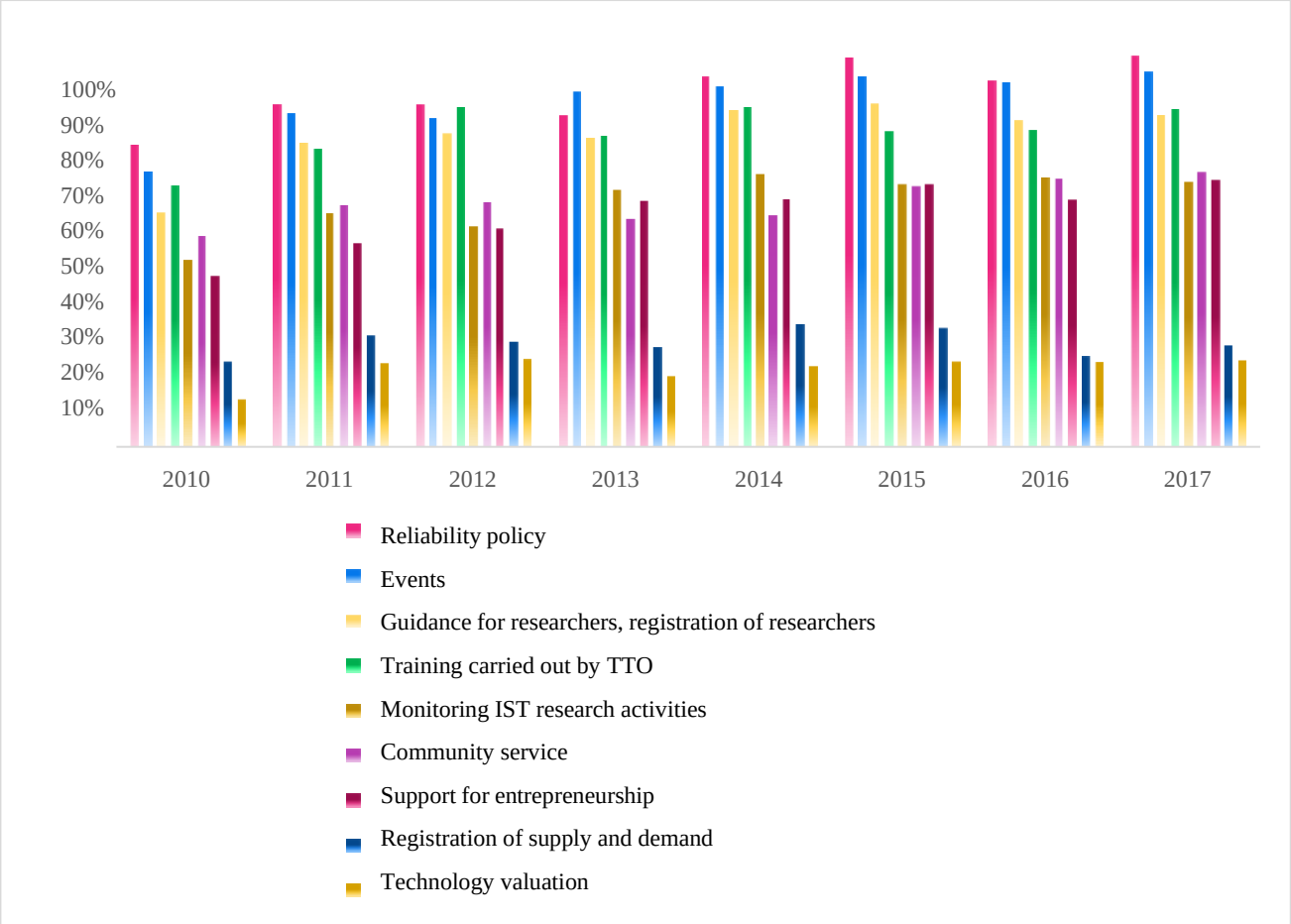
Figure 2: Essential activities implemented



According to Silva and Ribeiro (2019), who mapped the activities of TTOs in thesoutheastern region of Brazil, they found that specific activities aimed at innovation at the IST, for example, creating business intelligence and technology prospecting investigations in the area of intellectual property, developing studies and strategiesfor the transfer of innovation generated by the IST, and minority participation in the share capital of industry not been developed and the insistence on implementation can have an impact on TT results. It can also be seen that applications for protection have been pouring in while the number of TT contracts is still low.

Figure 3 shows that complementary activities follow the same pattern as core activities in that the activities with the lowest incidence of implementation are related to interaction with third parties: "Community service", "Support for entrepreneurship", and "Registration of supply and demand".

Figure 3: Complementary activities implemented

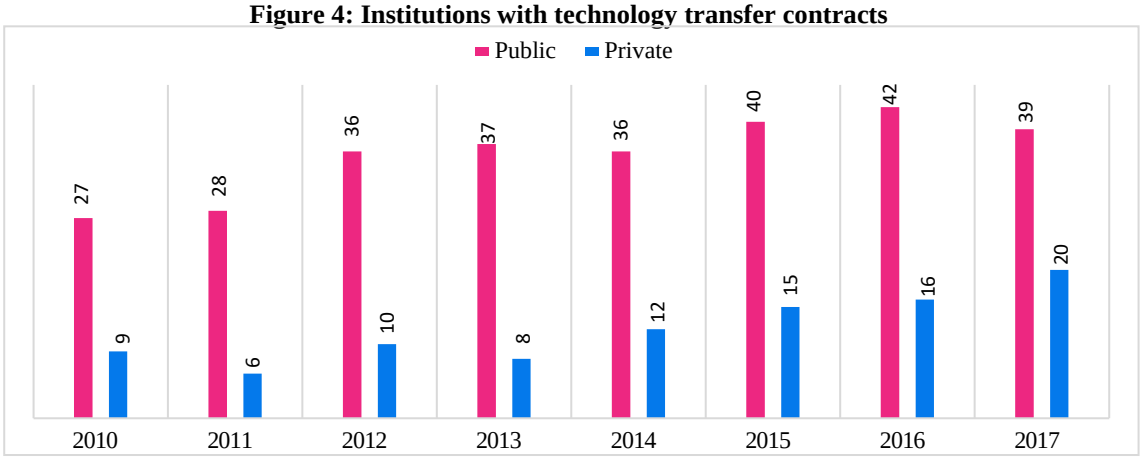


One of these indicators is the low rate of implementation of the "supply and demand register" activity, which would be an interesting tool in the search for partnerships to solve real problems in the production sector. Corroborating the analysis in the FORMICT reports, studies carried out by variousauthors in two regions of Brazil (the northeast, south, southeast and central-west of MinasGerais) show that most TTOs concentrate their efforts on depositing and protecting intellectual property, where intellectual property has so far only generated protection andmaintenance costs. There is no effective targeting of the knowledge developed in ISTs for future applications in production. The Centers are reduced to a simple patent office, i.e. they only carry out activities related to the protection of intellectual assets without envisioning their transfer (MACHADO et al., 2019; SANTOS, 2018).

The role of a TTO is not to be a mere IP office but an institution focused on innovation policy, in close collaboration with other players in the ecosystem, or, i.e. the strategic "bridge" to connect your IST to the market, which would promote the effective management of the IST's knowledge and, consequently, innovations. One of the main stages of the TT process is the valuation of technology, and according to FORMICT reports, this indicator is poorly implemented by TTOs. This stepis substantial, as it allows a price to be set, facilitates the determination of a form of collection, as well the design of the most appropriate transfer conditions to offer potential stakeholders (CABRERA; ARELLANO, 2019).

In the research carried out by Oliveira and Frey (2021), which sought to understand how prepared Brazilian TTOs are to value technologies, the analysis of the results showed evidence that TTOs still face several difficulties, the most important of which are the need for qualified personnel and the lack of specific valuation methods forthe reality of the Brazilian TT context. In Figure 4, based on the data obtained through FORMICT in the base year 2010,of all the ISTs that filled in the forms, only 36 (thirty-six) institutions, public and privatecombined, formalized a contract, and in the last base year analyzed, 2017, only 59 (fifty-nine) institutions.

Figure 4: Institutions with technology transfer contracts



In this sense, it can be seen that there has not been a significant increase in the number of public institutions signing contracts over the years, with an average of 35 institutions per year. This finding shows that the number of institutions seeking to transfer their intellectual property assets has remained the same. It seems that the institutions that have signed technology transfer contracts are almost always the same institutions.

R&D and licensing contracts are recommended to boost technical competence andenable incremental innovations. The most appropriate mechanisms for building technical competence and carrying out discontinuous innovation activities are consortia,research funds and *joint ventures* (PIRES, 2020; DIAS and PORTO, 2014; GILS, VISSERS, & WIT, 2009).

Once the technology transfer has been signed, it is necessary to carry out TT management, which consists of supervising the transfer processes to ensure compliancewith the conditions of the partnerships signed for the supply of knowledge, to protect therights inherent in the property, and to guarantee the correct destination of the financial resources resulting from the commercialization of the product.

VI. CONCLUSION

This research looked at the importance of Technological Innovation Centers in ISTs, as well as their relevance in boosting the process of technology transfer and stimulating the country's economic development, the productivity of university knowledge, the technological development of companies and people's quality of life. Data was analyzed from the implementation of the TTOs through Innovation Law No. 10.973, of December 2, 2004, until 2017, by collecting consolidated data from FORMICT reports, INPI and bibliographic research (articles, dissertations and theses). It focused on the performance of TTOs in developing the competencies assigned to them by law, which have a direct impact on the progress of the technology transfer process and, consequently, are of great importance for innovation in the country.

The performance of the TTOs is fragile since there has been a significant increase in the number of TTOs implemented, which has had a positive impact on the number of intellectual properties generated in the ISTS, but there is a need for advice, a plan that guides actions in the structuring and operationalization of the centers and facilitates internal and external relations, with systematic and unbureaucratic work processes, with a qualified team, with the aim of successful institutional policy management. The findings corroborate the good performance of TTOs over the years when it comes to implementing innovation policy. Since the enactment of the Law in 2004, TTOs have played an important role in this regard, but their initiatives in promoting innovation have been incipient.

Interaction with third parties is another factor that can greatly contribute to the success of TTOs, and it is necessary to expand actions and strategies to promote innovation, whether through the use of laboratories, equipment, materials, facilities, etc. It is important to develop activities (community service, support for entrepreneurship, improving the internal relationship with the researcher-inventor, registering supply and demand, supporting collaborative research, valuing intangible assets) that have an impact on the results of technology transfer and effective targeting of the knowledge developed at ISTs for future applications in production and beyond.

The results presented, in a general overview of TT actions, showed that, in the years analyzed, Brazilian ISTs have signed a considerable number of technology transfer contracts. Although the number of ISTs signing them is still small. This study mapped the current status of technology transfer contracts signed, and it was possible to conclude that they are an important instrument for transformation. On the other hand, there has not been a significant increase in the number of public institutions that have signed TT contracts, and they are almost always the same institutions, but there is a tendency to increase the number

of contracts that are geared towards research partnerships, rather than developing new technologies individually.

Therefore, the data collected for this study could be the subject of more in-depth analysis in future studies, as it indicates changes in the behavior of Brazilian ISTs and highlights the transfer of technology as a basis for sustained development as a primary factor in Brazil's scientific and technological development.

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