Received on November 16, 2017 / **Approved on** November 05, 2019
Responsible Editor: Priscila Rezende da Costa
Evaluation Process: Double Blind Review
e-ISSN: 2318-9975

https://doi.org/105585/iji.v8i1.252

TECHNOLOGY TRANSFER OFFICES AS PROMOTERS OF TECHNOLOGY, INNOVATION AND REGIONAL DEVELOPMENT IN MEXICO

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ABSTRACT

Objective of the study: The main objective of this research work was to analyze the importance of a Technology Transfer Office (TTO) as an innovation promoter in regional development in Mexico.

Methodology/Approach: An analysis bibliographic was used, application of surveys and generation of indexes. In 2014, a survey was applied to 131 TTOs to measure their impacts.

Originality/Relevance: To perform this analysis, we used a self-generated indicator, an index that measures the degree of specialization by geographic region and economic sector, using indicators of regional agglomeration as a basis. The agglomeration model generated was composed of national patent applications, international patents, utility models, industrial designs, and trade secrets.

Cite it like this:

Beltrán-Morales, *L.*, Almendarez-Hernández, M., Flores-Delgado, V., Trejo-Berumen, K., Lagunas-Vázques, M. & Ortega-Rubio, A. *(2020). Technology Transfer Offices as promoters of Technology, Innovation and Regional Development in Mexico. International Journal Of Innovation, 8(1), 121-136. http://dx.doi.org/10.5585/iji.v8i1.252.*

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Main results: The results by geographical area in Mexico, were the Northwest, specializing in aquaculture, fisheries, aeronautics and agriculture; the Northeast, in biotechnology, chemistry and metallurgy mechanics; the Center, in automobile, energy, and software; the West, in aerospace, automobile, chemistry and metallurgy mechanics; the Southeast, in food industry, construction, and mining.

Theoretical/methodological contributions: We found that the specialization of the TTOs among the various productive sectors in Mexico has contributed to the highest rates of growth in patent registration in the Latin American region.

Social/management contributions: Although contributions generated in protecting intellectual property at international level are still insufficient, we believe we are on the right track. At least Mexico started to generate the innovation ecosystem that other countries began four decades ago.

Keywords: Technology Transfer Office, Intellectual Property, Innovation, Regional Development.

ESCRITÓRIOS DE TRANSFERÊNCIA DE TECNOLOGIA COMO PROMOTORES DE TECNOLOGIA, INOVAÇÃO E DESENVOLVIMENTO REGIONAL NO MÉXICO

RESUMO

Objetivo do estudo: O principal objetivo deste trabalho de pesquisa foi analisar a importância de um Escritório de Transferência de Tecnologia (ETT) como promotor de inovação no desenvolvimento regional no México.

Metodologia/abordagem: Uma análise bibliográfica foi utilizada, aplicação de pesquisa estatística e geração de índices. Em 2014, foi aplicada uma pesquisa em 131 ETTs para medir seus impactos.

Originalidade/Relevância: Para realizar essa análise, foi utilizado um indicador autogerado, um índice que mede o grau de especialização por região geográfica e setor econômico, utilizando como base indicadores de aglomeração regional. O modelo de aglomeração gerado foi composto de pedidos de patentes nacionais, patentes internacionais, modelos de utilidade, desenhos industriais e segredos comerciais.

Principais resultados: Os resultados encontrados por região geográfica no México foram: Noroeste, especializado em aquicultura, pesca, aeronáutica e agricultura; Nordeste, em biotecnologia, química e metalurgia; Centro, no setor automobilístico, energético e de software; Ocidente, nos setores aeroespacial, automobilístico, químico e metalúrgico; Sudeste, na indústria alimentícia, construção civil e mineração.

Contribuições teóricas/metodológicas: Descobriu-se que a especialização dos ETTs entre os vários setores produtivos do México contribuiu para o aumento da taxa de crescimento dos pedidos de patentes na América Latina.

Contribuições sociais/para a gestão: Embora as contribuições geradas na proteção da propriedade intelectual em nível internacional ainda sejam insuficientes, acreditamos que estamos no caminho certo. Pelo menos o México começou a gerar o ecossistema de inovação que outros países começaram há quatro décadas.

Palavras-chave: Escritório de Transferência de Tecnologia, Propriedade Intelectual, Inovação, Desenvolvimento Regional.

OFICINAS DE TRANSFERENCIA DE TECNOLOGÍA COMO PROMOTORAS DE TECNOLOGÍA, INNOVACIÓN Y DESARROLLO REGIONAL EN MÉXICO

RESUMEN

Objetivo del estudio: Esta investigación analizó la importancia de las Oficinas de Transferencia de Tecnología (TTO) como promotoras de la innovación en el desarrollo regional en México.

Metodología/enfoque: Un análisis bibliográfico fue usado, la aplicación de encuestas y la generación de índices. En 2014 se aplicó una encuesta a 131 OTT para medir sus impactos.

Originalidad/Relevancia: Para realizar este análisis se utilizó un indicador autogenerado, un índice que mide el grado de especialización por región geográfica y sector económico, utilizando como base los indicadores de aglomeración regional. El modelo de aglomeración generado estuvo compuesto por solicitudes de patentes nacionales, patentes internacionales, modelos de utilidad, diseños industriales y secretos comerciales.

Principales Resultados: Los resultados por área geográfica en México fueron: el Noroeste está especializado en acuicultura, pesca, aeronáutica y agricultura; Noreste en biotecnología, química y mecánica metalúrgica; el Centro en automóviles, energía y software; Occidente en industria aeroespacial, automotriz, química y metalúrgica; Sureste en industria alimentaria, construcción y minería.

Contribuciones Teóricas/Metodológicas: Los hallazgos revelan que la especialización de las OTT entre los diversos sectores productivos en México ha contribuido a las tasas más altas de crecimiento en el registro de patentes en la región de América Latina.

Contribuciones sociales/gestión: Aunque las contribuciones generadas para proteger la propiedad intelectual a nivel internacional aún son insuficientes, éstas van por el camino correcto. Al menos México comenzó a generar el ecosistema de innovación que otros países comenzaron hace cuatro décadas.

Palabras clave: Oficina de Transferencia de Tecnología, Propiedad Intelectual, Innovación, Desarrollo Regional.

Introduction

Deriving from a tendency for countries to achieve economic growth through innovation and knowledge, the concern to analyze those fostering environments and elements appears to be known as National Innovation System (SNI for its abbreviation in Spanish), which are compounds by government institutions, industry associations, and academic experts Herstatt et al.(2008). The strategic behavior of enterprises, and their interaction with other companies, universities, research centers, and other institutions that are at the center of the innovation process define what Freeman (1987) and Nelson (1992) call the Innovation System.

An innovation system can be considered as a set of actors, such as companies and other organizations and institutions that interact in generation, dissemination, and use of new knowledge within the production process that is economically profitable. Innovation Systems are involved in different spheres called environments, which refer to the events and conditions that influence the system behavior, such as economic and legal, financial, scientific, technological, and productive. As a result of the developmental environments, link structures appear to establish and strengthen the relationship between them and make the interaction between these environments more efficient (Conesa, 1997).

The technology transfer offices (TTO) act as intermediaries (link

structures) between academic research and the productive sector, especially where their purpose is to contribute to the success of the technology transfer process. Within this process, TTOs are founded from an institutional point of view to facilitate technology transfer, such as linking academic research with financial capital, stimulating social interaction, and seeking greater opportunities between technology users and providers (Hülsbeck et al., 2013).

According to Bessant and Rush (1995), technology transfer can be understood as the process by which technology moves with outsourcing. When an internal need to change the organization or the country itself cannot be satisfied, it causes the acquisition of the technology required from other entities outside the organization. For Amesse and Cohendet (2001), technology transfer has a more practical sense, defining it as a specific process of knowledge transfer that depends on the ways in which companies and other institutions manage knowledge, particularly absorbing capacities and transmitting strategy.

O'Keefe and Marx (1986) found that technology transfer can be applied, therefore, it must be practical. They define it as a process that gives support to implementing research efforts and say it is an investment rather than a cost; this process must be efficient and at a certain time. They also suggest three steps to carry out this process: planning, marketing, and training.

There is lag in Latin America of technology transfer compared to developed countries, as shown by the number of patents generated in recent years. In spite of the design of policies aimed at creating institutional structures such as Technological Transfer Offices (OTT), the differences persist, mainly due to the slow diffusion of intellectual property mechanisms (Stuart and Olaya, 2018; Crespi and Dutrénit, 2014; Ísmodes, 2015). Another aspect that explains the slowdomn in the Latin American region is the orientation of an intellectual property policy focused on attracting foreign direct investment rather than the generation of own knowledge (Abarza and Katz, 2002; Stuart and Olaya, 2018). Recently it has emerged in the interest in the region to encourage technology transfer.

The Latin American countries that generate the largest number of patents are Brazil (7505), Mexico (2522), Chile (876) and Argentina (766) WIPO (2017). In terms of articulation and generation of patent applications with Higher Education Institutions stand out Brazil (more than 1500), Mexico (more than 500) and Argentina (30) (Barro-Ameneiro, 2015).

Mexico has the highest annual growth rate in Latin America in generation of patents from IES, with 18.3% for the period 2010-2010. Such growth is due to the increase in specialized financial and human resources, infrastructure and OTT. The distribution of the 131 OTT that make up the Network of Technology Transfer Offices is as follows: 23% belong to private companies, 11% Research Centers, 9% Public Universities, 8% Private Universities and 50% belong to Institutes Technological, governmental agencies among others (Stuart and Olaya, 2018). The Transfer Offices have two main functions as intermediaries between academic and productive sectors. The first occurs within the academic institution through the management and valuation of the added value of research in the productive sector. The second function is to encourage local business innovation through the link IES-company (Becker, 2013; Codner et al., 2013; Stuart and Olaya, 2018; Manderieux, 2011).

Another important aspect of the OTT is to identify institutional research capacity, communicate inventions and support intellectual property management (Codner et al., 2013; (Stuart and Olaya, 2018).

The literature identifies three OTT models to which the IES can adjust according to their Technology Transfer activities, namely: internal model, consists of the operation of the office is within the structure of an IES; external model, the office is not part of the IES and works independently; mixed or hybrid model, occurs when the office is made up of a combination of the previous ones (Alvarado-Moreno, 2018; Brescia et al. 2016; Derrick, 2015). On the other hand, the efficiency of the OTT depends on the clarity of the mission, transparency in procedures, specialized human resources and an entrepreneurial environment, as well as an adequate business model to transfer the knowledge (Young, 2007; Alvarado-Moreno, 2018).

The main objective of this research work was to analyze the importance of a Technology Transfer Office (TTO) as innovation promoter in regional development in Mexico. Also, perform an analysis of the Technology Transfer Offices in Mexico, mainly in intellectual property and generation of technology-based companies by sector of activity of the economy.

Material and methods

To perform this analysis, we used a self-generated indicator, an index that measures the degree of specialization by geographic region and economic sector, using indicators of regional agglomeration as a basis, which were originally used by Crocco et al. (2006) and were adapted by Godínez and García (2010) to detect local production arrangements in Mexico. Even though these indicators were used to measure specialized labor by the manufacturing sector, its transformation by changing variables, conceptual and technical relationship, allowed us to find agglomerations applied to the case of intellectual property applications by sector or area of knowledge.

The measurement model was structured by national and international patents, utility models, industrial designs, and trade secrets. The concentration index by TTO specialty is composed of coefficients of national relative participation (PRN for its abbreviation in Spanish, equation 1) which measures the contribution of a state (j) in a nation (R), and it can also measure knowledge ready for the market (E). It is worth to highlight that at national level, knowledge related to the sectors (i) Biotechnology, ICT, chemistry - metal mechanics and health are highly relevant since they make up the greatest number of TTO efforts in applications for industrial property. The coefficient must be between zero and one to be relevant; the closest to one, the greatest relevance it will have.

$$1)\quad PRN = \frac{E_j^i}{E_R^i}\,; 0 \leq PRN \leq 1$$

The location coefficient by area of knowledge (QLR), equation 2, shows the specificity of a sector in a region. This coefficient indicates that the activity is very relevant to the locality and the nation when it is positive but less than one. If greater than one, it indicates a greater relevance to the country.

$$2)\quad QLR = \frac{{E_j^i}/{E_j}}{{E_R^i}/{E_R}}\,; 0 < QLR$$

Finally, Hirschman-Herfindahl modified is a coefficient showing the weight of a sector in the local technological structure by correcting the relative participation of the nation in applications for intellectual property (equation 3). The value of this coefficient should be greater than or closer to the average corrected by the first standard deviation and it must be positive.

$$3)\ HH = \frac{E_j^i}{E_R^i} - \frac{E_j}{E_R}\ ; HH\ \in \mathbb{R}$$

The coefficients described include the index measuring the degree of specialization by geographic region of the TTOs. The database used in the regional agglomeration indexes was compiled through a survey applied to 131 OTTs members of Mexican Network of Technology Transfer Offices (OTT Network) in the year of 2014. A series of indicators was constructed to request information to the OTTs: 1) patent applications and registrations; 2) applications and utility model registrations; 3) industrial design applications and registrations; 4) industrial secrets; 5) trademark applications and trademark registrations; 6) number of licenses; 7) generation number of contracts of R and D; 8) number of technical consultancies; 9) number of innovation projects developed; 10) number of spin-outs generated. Only the first four indicators were used to feed the regional agglomeration indices.

Results

Technology Transfer Offices in Mexico

Recently, Technology Transfer Offices in Mexico and their links with the formation of the triple helix mentioned by Etzkowitz and Leydesdorff (1995), consisting of the linkage between the productive sector with academia in conjunction with government support, intend to take innovation as an economic growth engine (Cuervo, 2008).

In Mexico, the initiative to create TTOs became important for CONACYT in 2008 with the AVANCE program that aims to boost and identify opportunities for creating businesses based on the exploitation of scientific and technological (CONACYT, 2015a) development. It establishes the search for facilitating commercialization and transfer of technologies developed by institutions generating knowledge user sectors by identifying and integrating investors and sponsors (CONACYT, 2015b).

On the other hand, the Ministry of Economy in 2010, through the Sectorial Innovation Fund called FINNOVA, began working with the Technology and Knowledge Liaison Units (UVTC for its abbreviation in Spanish) in the country (SE, 2015a), generating a certification for those interested in having the name and activities concerning a TTO in 2012, and Centro de Investigaciones Biológicas del Noroeste, S.C. (CIBNOR) was the first to obtain the certification (SE, 2015b). After that, through a collaboration between the Ministry of Economy, CONACYT and several TTOs that were in the certification process, the TTO Network was created in La Paz Baja California Sur, Mexico in June 2012. The TTO Network has the mission of knowledge contribution to society by defining the activities of the TTOs to facilitate their development and professionalization and function as a union representative before Mexican authorities in technology, boosting the development of public policies for innovation.

As part of the activities, the TTO network should perform various congresses in Mexico and collaborate with other technology networks and international organizations, such as the Association of University Technology Managers (AUTM), Public Intellectual Property Resource for Agriculture (PIPRA), the Organization of American States (OAS), among others, to support the training of highly specialized human capital in technology transfer and in sharing good practices (Red TTO, 2015).

TTOs distribution in Mexico

Mexico has at least 131 TTOs, of which 117 are certified by FINNOVA and 14 are in the certification process. The TTO Network consists of 97 TTOs, which are

grouped into six geographical areas (TTO Red Indicators 2015). The regional classification is due to the geographical environment and the ease of interacting between these states, both socially and culturally, and with the accessibility that allows concentrating TTOs by region making the analysis easier. The geographical zones and states with revised data by January 2015 are:

- Northwest: Baja California (4), Baja California Sur (2), Chihuahua (8), Sinaloa (4) and Sonora (4).
- Northeast: Coahuila de Zaragoza (7), Durango (0), Nuevo Leon (7), San Luis Potosí (3) and Tamaulipas (2)
- Center: Guerrero (0), Hidalgo (3) Mexico (6), Morelos (6), Puebla (8) and Tlaxcala (1)
- West: Aguascalientes (0), Colima (1), Guanajuato (5), Jalisco (7), Michoacán de Ocampo (1), Nayarit (0), Querétaro (6) and Zacatecas (0).
- Southeast: Campeche (0), Chiapas (2), Oaxaca (0), Quintana Roo (0), Tabasco (1), Veracruz (4) and Yucatan (7).
- Mexico City: Mexico (32)

One of the activities of the TTO Network in Mexico was the application of a survey in 2014 to 131 TTOs to measure their activity.

The main activities that a TTO execute in Mexico are:

a) Support in intellectual property

b) Technical services to innovation fund management with the private sector and university

c) Generation of R & D contracts

d) Licensing

e) Technical Consulting

f) Creation of Spin - outs

g) Establishment of science parks

h) Provision of seed capital and technology monitoring

It is important to clarify that not all TTOs perform all activities; some perform only one or more of them. All TTOs in Mexico perform management or support in intellectual property and offer management advice or manage innovation funds.

Intellectual property, innovation fund management and generation of technology-based companies 2010-2014 in Mexico

According to the results, the survey found that a total of 171 industrial secrets, 623 trademark applications, 482 applications of copyright software, 923 applications of national patents, 126 international patent applications, 177 model utility applications, and 116 industrial design applications were generated. In the same period 529 trademarks, 341 records copyright software, 171 records of national patents, 54 international patent registrations, 57 registrations of utility models, and 48 industrial design registrations were registered.

The number of technology licensing from 2010 to 2014 from the TTOs in Mexico was low compared to the number of records of intellectual property with 186 licenses; however, the sale of technology transfer packages compensated it because we promoted 1547 technology transfers to the productive sector. The generation of R & D contracts and technical consulting from 2010-2014 of TTOs in Mexico were 1497 with and to the public sector and 2801 to the private sector. Technical

consultancies (3945) were generated during the last five years. As for fund management, the TTOs developed 1861 innovation projects of which 46% obtained approval in this period.

In Mexico, in the period from 2010-2014, the TTOs generated 114 spin-outs related to different sectors and industries, of which 3 were related to aquaculture and fisheries, 1 to agriculture, 2 to food, 19 to automobile, 17 to biotechnology, 2 to construction, 2 to footwear, 2 to energy, 1 to livestock, 1 to chemistry and metallurgy mechanics, 14 to health, 50 to information and communications technologies (ICT), and 9 to others. When taking into account only those sectors with high relevance at national and local level and discarding those with low participation at the national level, the specialization areas according to zone were found to be as follows:

- Northwest: Aquaculture and Fisheries, Aeronautics, Agriculture, Biotechnology, and Livestock
- Northeast: Biotechnology, Chemistry and Metallurgy mechanics
- Center: Automotive, Energy, and Software.
- West: Aeronautics, Automotive, Footwear Industry, Chemistry-metallurg mechanics and Software
- Southeast: Food, Construction, and Mining
- Mexico City Area: Health

Discussion

The role of the Technology Transfer Office varies depending on its type, for example, there are traditional university structured TTOs that are located within the university; private profit TTOs that are created directly by the university or indirectly by research foundations with more autonomy in licensing and compensation systems; and research non-profit foundation TTOs that tend to be independent and separate from the university structure with financial autonomy and in selecting the licensing strategy to implement it; their disadvantage is the difficulty of attracting capital and lack of market orientation because of their nonprofit status (Markman, et al., 2005).

According to a study by the European Commission (2009) and independent of its type, the Technology Transfer Offices have the main functions listed below:

a) Registration of patents, including the previous steps as detection and assessment

b) Licensing

c) Management of research contracts, including finding partners, signing contracts, legal issues

d) Support for spin outs including services such as business model development, support for the creation of the company, seeking funding

e) Spin out financing through venture capital or taking equity

This same study shows that 64% of TTOs support the creation of spin outs. Finally, some activities will depend more often than others on the model chosen. On the other hand, their efficiency and impact are measured by the number of technology-based companies created, negotiated licensing, collaboration agreements with companies, number of patents registered, and declarations of invention, among others. The literature indicates that international assessment and technology transfer issues are not

novel, in some countries more than 40 years have been devoted to identifying potential technologies that penetrate the market.

In the United States, with the creation of the Bayh Dole Law in the 80s, further impetus to the creation of TTOs were generated. US TTOs starting in academic institutions and university cover the budget in most cases, with the target to transfer the new developments to the productive sector. Today, practically every university in the U.S.A. has a TTO, which includes in its activities protecting the intangible goods of the institution related to intellectual property (Connors, 2001). For example, in the United States, the University of Arizona has the "Advanced Technology Transfer Program" to identify their technologies (K. Smith, personal interview, May 5, 2011).

The University of Texas at Austin through the IC2 Institute has the Master's Program of Marketing Science and Technology based primarily on learning the "Quicklook" methodology that helps players in technology transfer identify technologies close to the market (Zehner II, 2005).

In Europe, approximately 1,400 TTOs were identified in 2009, where most started as a liaison office of industry and services developed by professionals to promote the commercialization of staff research results. Over time, their staff has achieved greater specialization for the evaluation of inventions disclosed, patents, licenses, development and financing of a technology-based company. With the Bayh Dole legislation, institutions were required to implement IP policies with emphasis on patents and licenses (European Commission, 2009). At university level, Carree, et al. (2014) showed that academic activities, such as teaching, research, and intellectual property rights affected economic growth when associated with new business ventures. In the UK, the University of Oxford has a Technology Transfer Office "Isis Innovation Ltd". Cambridge University has its own consulting company "Cambridge Technology Enterprise". Both universities, Oxford and Cambridge, have a similar transfer method; however, they have said that their primary way of evaluating technologies has been the vast experience in these matters (C. Moody, S. Vyakarnam, personal interview, January 11, 2011).

In Germany, the company INNOWAYS in Leipzig developed the technological know-how, especially on issues such as biotechnology and technology mechanics, know-how in management, especially in the areas of innovation processes, and the creation of international marketing channels; they have experience in international projects with a special focus on Spanish-speaking countries.

In Spain, an Internet portal "Marketplace Tecnológico Madrid" (2015) emerged to facilitate commercialization of the regional scientific research results and promoted the use of knowledge by the business environment, (Berges, 2007). The portal promotes the Office of Technology Commercialization in Madrid and the General Director of Universities and Research of the Community of Madrid. The European Patent Office also developed an instrument called the IPscore® 2.2, with the collaboration of the Ministry of Madrid, which offers both qualitative and quantitative assessment. In addition, IPscore® 2.2 produces graphics and a report that facilitates communication of the evaluation results (EPO, 2015).

According to the previous information, the TTO is a crucial bridge between scientific work, the productive, governmental, and social sectors with the primary mission to support the academic staff in identifying and managing intellectual assets of the organization, including the protection of intellectual property and transfer or license rights to other parties to improve the perspective for future development (Comacchio et al.,

2012). Moreover, according to Young (2010), TTOs assist investigators in transferring research results of the institution to the industry for commercial use resulting in economic development and public benefit.

The most recent advances in economic growth literature have argued that technological progress is one of the main determinants of economic growth (Romer, 1990; Grossman and Helpman, 1991a, 1991b; Aghion and Howitt, 1992). In this sense, empirical evidence suggests that the protection of property rights has a positive impact on economic growth (Gould and Gruben, 1996; Falvey et al., 2006; Kim *et al.*, 2012). By this situation and the demands of the constantly changing technological environment, it is necessary to measure achievement or performance of the TTO. The quantitative instrument resorted to effect the above are performance metrics. Gardner *et al.* (2010) mentioned that the reasons for measuring the effectiveness of transfer activities are to:

a) Demonstrate the benefit to society of advances in knowledge

b) Educate the need of society for innovation

c) Guarantee a sufficient return on investments

d) Provide reference points for comparison across the industry.

e) Promote competition in the global market

f) Support future funding requests

A review by Tseng and Raudensky (2014) on investigations that have focused on developing metrics indicated that conventional performance metrics are as follows:

1) Number of invention declarations

2) Number of patent applications

3) Number of patents granted

4) TTO income

5) Number of signed licensing

6) Number of spin outs formed

These six indicators are named as "core" by the European Commission (2009), designation resulting from the call to a group of experts to prepare a report on knowledge transfer metrics. The first three indicators measure the potential commercialization of scientific knowledge from research institutions and the other three the use of science and technology by the enterprises. The six indicators describe the quantitative results of all the steps in the process of technology transfer, considered income of the TTO as the main one, as they are in the business of covering its expenses; it is the best reference point that reflects their success (Tseng and Raudensky, 2014) and stimulates their staff to increase their productivity, provided there is a scheme of bonuses or prizes.

On the other hand, there are indicators named as "non-core" by the European Commission (2009). Their constructions are based on traditional work developed by metrics USA and consist of six elements:

1. Resources of Technology Transfer Office

- TTO start year
- Level of TTO staff
- TTO commercialization costs / budget
- Fees, legal fees / costs of Intellectual Property Protection

2. Research

- Research expenses
- Employment Research

• Gross value of contract

3. Intellectual Property

• EPO Patent Applications

• USPTO Patent Applications

• Current Active Patent

4. Licensing

• Licenses with spin -outs

• Licenses with small businesses

• Licenses with large companies

• Licenses for non-commercial organizations

• Exclusive licenses

• Non-exclusive licenses

• Software licenses

• Active licenses, options, and assignments

• Licenses, options, and assignments that generate active income

5. Establishment and equity spin-out

• Spin-out in operation

• Spin-out with public research organizations / TTO equity

• Employment in spin-outs

• Billing in spin-outs

6. Income

• Income patent licensing

• Income software license

• Income licenses of other intellectual property

Other indicators are qualified as secondary (Gardner et al., 2010) but correspond to the segment of basic metrics including total income from royalties, number of full-time professionals in the TTOs, and legal expenses are in intellectual property protection. As to information for calculating indicators measuring their performance, TTOs have found restrictions. Among them, one is the lack of an information system that would constantly be updated (every year), so it could be available as a primary source. Some TTOs records in logbooks and information are outdated, making it difficult to estimate data collection metrics. The deficit of staff to carry out each of these activities is another limiting factor that relates to the above.

It is important to note that indicators should not only remain in the stage of assessment but they must also be interpreted correctly to achieve the function of providing relevant quantitative information to decision makers to improve their planning in the field of technology transfer and assign TTO resources efficiently.

According to the European Commission (2009), several channels are used to transfer technology, such as: networks, continuing professional development, consulting, collaborative research, contract research, licensing, technology-based companies, and education. In applied technology transfer, the actors involved mainly in the process are the researcher, specialist in technology transfer, and technology user. It is important to have a declared technology transfer target in the project (O'Keefe and Marx, 1986).

On the other hand, several studies suggest that certain brokers operated as specialized consultants in the technology transfer process because they focused on finding various uses and applications of technology, contributing to knowledge pollination (Aldrich and von Glinow, 1992; Howells, 2006).

Seaton and Cordey-Hayes (1993) have identified three stages to carry out the activity of intermediaries: (1) exploration and recognition; (2) communication and assimilation; (3) application. In addition, TTOs contribute within the institution or research centers to access financing, collaboration of

research topics, and development and integration of students to careers in the productive area (Rintoul and Lumb, 2012). Therefore, transforming the TTOs as articulator units of universities and research centers with the productive sector, one of its main challenges is to find a strategy for protecting intellectual property (IP) to defend the interests of both the inventor and the institution and find that distinctive innovation that will allow the productive sector to find a better market position compared to the competition. The specialization of the TTOs among the various productive sectors in Mexico has contributed to the highest rates of growth in patent registration in the Latin American region, which is consistent with that reported by Stuart and Olaya (2018).

Conclusions

It is important to highlight that as technology transfer activities of the TTOs increase, some regions or sectors approach specialization with greater relevance both in the region and the nation, creating new parameters on the criteria of expertise in the fields of intellectual property, technological development, and innovation.

Currently in Mexico, although contributions generated in creating new technology-based companies, licensing universities, linking research centers to the business environment, and protecting intellectual property at international level are still insufficient, we believe we are on the right track. At least Mexico started to generate the innovation ecosystem that other countries began four decades ago.

As for measuring the impact of the TTOs, it is important to note that indicators should not only remain in the assessment stage, but they should also be interpreted correctly to provide relevant quantitative information to decision makers to improve their planning in the field of technology transfer and efficiently allocate resources and incentives.

Acknowledgments

We would like to thank the National Council of Science and Technology of Mexico (CONACYT) project number PN-2017/6113. Thanks to the Mexican Network of Technology Transfer Offices (Red OTT), The Northwest Biological Research Center of Mexico (CIBNOR) and CIBNOR staff for comments and sharing their opinions. We are also grateful for the feedback provided by the Editor in Chief and three reviewers, which helped us to improve an earlier version of this manuscript.

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