

Chapter 2 Four dimensions for the commercialization of technologies in public institutions of higher education (IHE)

Capítulo 2 Cuatro dimensiones para la comercialización de tecnologías en instituciones públicas de educación superior (IES)

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Abstract

An essential element in the scientific and technological development has been the institutions of higher education (IHE), their role in economic development has been transcendental. The IHE's contribute to innovation in the development of applied research aimed at generating useful technologies for society, in incorporating new technologies and in the direct or indirect application of technological innovations. The aspects worked by IHE are research, the generation of knowledge and technology, however, the challenge that currently arises for the IHE's refers to the approach and management of their structures and actions and the preparation of their resources in the sense to place the technologies generated at the disposal of the market and society. In this context, the objective of this work was the application of a radar framework of critical success factors (RFCSF) for the commercialization of technologies in public universities, to a Technological Institute of Higher Studies in Mexico. The RFCSF allows monitoring four dimensions (Strategy and management, Culture and Structure, Market and Technologies and finally Individual Competencies) and sixteen indicators associated with these dimensions, in order to provide a diagnosis and improvements in the technology commercialization process.

Technological transfer, Technological commercialization, Public Institutions of Higher Education

Resumen

Un elemento esencial en el desarrollo científico y tecnológico han sido las instituciones de educación superior (IHE), su papel en el desarrollo económico ha sido trascendental. Las IES contribuyen a la innovación en el desarrollo de la investigación aplicada orientada a generar tecnologías útiles para la sociedad, en la incorporación de nuevas tecnologías y en la aplicación directa o indirecta de las innovaciones tecnológicas. Los aspectos trabajados por las IHE son la investigación, la generación de conocimiento y la tecnología, sin embargo, el reto que se plantea actualmente para las IHE se refiere al planteamiento y gestión de sus estructuras y acciones y a la preparación de sus recursos en el sentido de poner las tecnologías generadas a disposición del mercado y de la sociedad. En este contexto, el objetivo de este trabajo fue la aplicación de un marco de radar de factores críticos de éxito (RFCSF) para la comercialización de tecnologías en universidades públicas, a un Instituto Tecnológico de Estudios Superiores de México. El RFCSF permite monitorear cuatro dimensiones (Estrategia y gestión, Cultura y estructura, Mercado y tecnologías y finalmente Competencias individuales) y dieciséis indicadores asociados a estas dimensiones, con el fin de proporcionar un diagnóstico y mejoras en el proceso de comercialización de tecnología.

Transferencia tecnológica, Comercialización tecnológica, Instituciones Públicas de Educación Superior

2.1 Introduction

The commercialisation (transfer, licensing and assignment) of technology has nowadays been consolidated as an important activity between universities, Higher Education Institutions (HEIs), companies and governments. This activity constitutes the main point in the construction of a knowledge-based economy, so that this economy is the tool that generates value and wealth. However, to achieve a knowledge-based economy, it is necessary that the knowledge generated in universities and HEIs is made available to businesses and society (Padilla, 2010; Kirchberger; Pohl, 2016; Sira, 2016; Miller; Mcadam; Mcadam, 2016).

The commercialisation of technologies depends on the effects of organisational and individual variables ranging from specialised institutes to the business sector (Santiago, 2006). It is a multidimensional, complex, multidisciplinary and inter-organisational process. For its monitoring and analysis it is necessary to take into account a large number of dimensions and factors (Sira, 2016). Therefore, it is necessary to use indicators that can provide elements for universities to plan and direct management, research and development processes for the commercialisation of technologies.

Over the last few years, a large number of studies have been carried out in order to identify actors and factors involved in the commercialisation of technologies generated in universities. These studies mainly involve Technology Innovation Nuclei in Universities - NITs or Technology Transfer Offices - TTOs; intellectual property, patents, university-firm relations and innovation management (Sorensen; Chambers, 2008; Hoye; Pries, 2009; Swamidas; Vulasa, 2009; Azevedo; Mazzoni; Silveira, 2013; Gómez; Daim; Robledo, 2013; Días; Porto, 2014; Vega-Jurado et al. 2017).

Moreover, it has been perceived that institutions have difficulties in carrying out a self-diagnosis to identify opportunities related to the production and commercialisation of technology. Therefore, it is necessary to know the reality of the factors that involve the commercialisation of technologies in universities and higher education institutions.

The first part of this paper presents the background and context of technology commercialisation in universities, section 2 considers the theoretical definitions that underpin this work, section 3 describes the methodology and research design, section 4 presents and discusses the data collected from one HEI based on the study and analysis of factors associated with the radar framework, the last section presents the conclusions.

2.2 Theoretical reference

In Latin America, where the production of knowledge is mainly carried out by public universities, it is necessary to investigate and propose significant changes in order to support innovation processes. Changes that consider substantial changes in the curriculum, academic structure, educational training, accompanied by fundamental transformations in administration, management and organisation of activities related to the invention, dissemination and commercialisation of knowledge and technologies (Didriksson, 2004; De Benedicto, 2011; Pastrana et al. 2020; Alonso et al. 2020).

With the advent of the Bayh Dole Act in the United States in 1980, the range of government-funded research expanded. The impact of this had a decisive influence on the impetus for the negotiation of research results and on the importance given to applied research by universities. Therefore, a new definition of the university's mission was necessary, the so-called "third mission" understood in a broad sense as the effective transfer of knowledge and technologies from the university to organisations and society (Rodríguez; Casani, 2011; De Benedicto, 2011).

At the same time, there is a general interest in what concerns the scientific field to establish a common element which is the generation and transmission of knowledge to contribute to local and regional development, for the empowerment of individuals in an environment of constant change (Calderón-Martínez, 2017).

In this way, the third mission can be formalised through three axes: a) the first axis, which explains corporate acceptance: where the university as a generator of technology in the R+D+i (Research, Development and Innovation) system, acts as an agent and at the same time as a space that dynamises innovation processes. That is to say, the generation of innovation that society needs, and which encompasses activities that universities carry out with different social agents with which they have a relationship and to which they transfer knowledge; b) Second axis, where the university, through the implementation of knowledge transfer processes, acts as an entrepreneurial agent. That is, an entrepreneurial university based on the process of commercialisation of university research results; and c) Third axis, of social cooperation, related to the extension function acting in the sustainable development and growth of the social community where the university is integrated, facilitating greater dissemination in R&D&I processes in the knowledge society and economy (Campos, 2007; Calderón-Martínez, 2017; Fernandes; O' Sullivan 2021).

As can be seen, the second axis points to the conception of the third mission with the entrepreneurial activity of the university, i.e. as a basic institution for the transfer of knowledge. The entrepreneurial university proposed by Etzkowitz et al. 2000; Etzkowitz, 2004, has as one of its objectives the development, commercialisation of technologies and support for the entrepreneurial culture. The entrepreneurial university is consolidated in new policies and culture for an adequate management of transfer instruments such as patents, licences or the creation of technology-based and social enterprises.

It should be noted that, in order to achieve an industrial, commercial and social goal, technology, from a general perspective, includes the knowledge, methods and materials used and generated. It commonly combines results with techniques in order to make science work in practice, therefore, it may also conceive processes as know-how and unique business practices (Anokhin, 2011).

2.3 Methodology

The present work is classified in the context of applied and descriptive research, with a qualitative approach associated with empirical research based on the Radar Framework of Critical Success Factors (González et. al 2018) (see Table 2.1 and Fig. 2.1), whose referential framework, endorsed by specialists, assesses four dimensions and sixteen variables that are used in the present work, which was tested in public universities in southeastern Brazil, so now it is intended to apply it to a TES in Mexico.

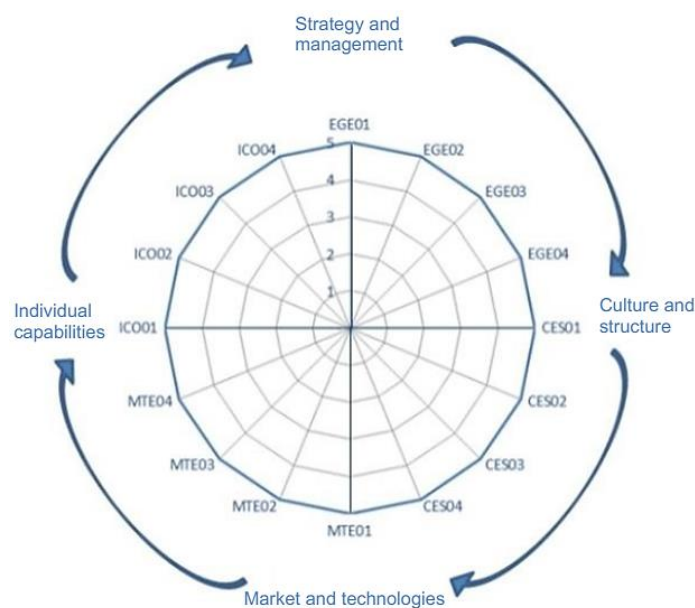
Table 3.1 shows four dimensions considered by specialists to identify the critical success factors for the commercialisation of technologies in public universities, each dimension contains four variables that serve as identifiers to assess each dimension. The radar graph (see Fig. 2.1) shows in a more visual way the values of each dimension and variable.

Table 2.1 Critical Success Factors (CSF) Framework for Commercialisation

Dimensions	Acronyms	Factors	Variables
Strategy and management	EGE	Public and governmental policies Strategic planning Top management Intellectual property	<i>EGE01</i> <i>EGE02</i> <i>EGE03</i> <i>EGE04</i>
Culture and structure	CES	Organisational Culture Entrepreneurial training Structure for technology development (Technological support) Structure and promotion of entrepreneurship	<i>CES01</i> <i>CES02</i> <i>CES03</i> <i>CES04</i>
Market and technologies	MTE	Market orientation University-business link Quality and applicability of technologies Dissemination of new technologies	<i>MTE01</i> <i>MTE02</i> <i>MTE03</i> <i>MTE04</i>
Individual skills	ICO	Reputation and quality of scientific output Know-how for innovation Entrepreneurial profile of researchers Problem-solving competence	<i>ICO01</i> <i>ICO02</i> <i>ICO03</i> <i>ICO04</i>

Source: González et al., 2018

Figure 2.1 FCE radar for commercialization of technologies in public universities, (radar graph)



Source: González, 2018

In this work we sought to apply the Radar Framework (González et. al 2018) in a Tecnológico de Estudios Superiores (TES) in the State of Mexico, where we used a questionnaire sent by email to staff related to the processes of entrepreneurship, intellectual property and commercialisation of technologies in universities.

The questionnaire was elaborated and applied considering the dimensions and factors related to the Framework. For each factor, two or more questions were created, with associated answers on a 5-point likert scale (1- strongly disagree to 5 - strongly agree).

15 people were contacted (Table 2.2), 2 administrative employees and 13 teachers of the TES case study from which 9 responses were obtained (2 administrative employees and 7 teachers).

Table 2.2 TES, contacted and number of responses obtained

Institution	Number of people contacted	Number of responses
TES	15	9

Source: Own elaboration

The data obtained were classified and represented in radar map graphs to allow for better interpretation and analysis of the information collected. This in order to provide an adequate view of the characteristics of the critical success factors that impact technology commercialisation. The results will be described below.

2.4 Results and discussion

In this section, the characteristics of the TES in the case study are presented. Additionally, a radar map is generated identifying the critical factors for the commercialisation of technologies based on the data collected.

2.4.1 Description of the TES

The TES that is the subject of this research is located in the North of the State of Mexico.

It has 12 degrees programmes (Electromechanical Engineering, Industrial Engineering, Computer Systems, Mechatronics Engineering, Business Management Engineering, Logistics Engineering, Chemical Engineering, Materials Engineering, Animation and Visual Effects Engineering, Tourism, Architecture and Public Accountant) and a master's programme in Industrial Engineering.

This TES is part of a programme for the strengthening of the academia-industry relationship based on the creation of linkage centres called: Centros de Cooperación Academia Industria (CCAI), which since 2014 have been implemented in four higher education institutions in the State of Mexico. The programme aims to promote the development of competences associated with the strategic areas identified in the State Development Plan and the Innovation Agenda, strengthening the infrastructure of the CCAIs in technological lines of cross-cutting application that are closely related to the productive sector.

The CCAIs are born from the link established by the Mexican Agency for International Development Cooperation (AMIXID) and South Korea through the Korean Development Institute (KDI) with the project "Improving Innovation Capacities for the Sustainable Development of the Mexican Economy" and with the advice of the Korea Polytechnic University (KPU) in the framework of the Knowledge Sharing Program (KSP), with the aim of improving the competitiveness and productivity of companies, mainly MSMEs in the State of Mexico, through basic and applied research projects, technology transfer and training of highly specialised human resources in technological areas.

It has been considered that this TES, for this study due to its characteristics, whose structure dedicated to linking and technology transfer is concentrated in a four-storey building, where it houses areas of: training in robotics, physical characterisation of materials, plastics and metal mechanics, work areas for companies, a training and meeting room, a reverse engineering laboratory, and spaces for stays of researchers and students. During the development and growth that has taken place in the almost seven years since its creation, it has made collaboration agreements with various companies with a tendency towards projects related to materials characterisation, additive manufacturing, polymers and process and product optimisation.

2.4.2 Radar Chart - Critical Success Factors for Commercialising Technologies

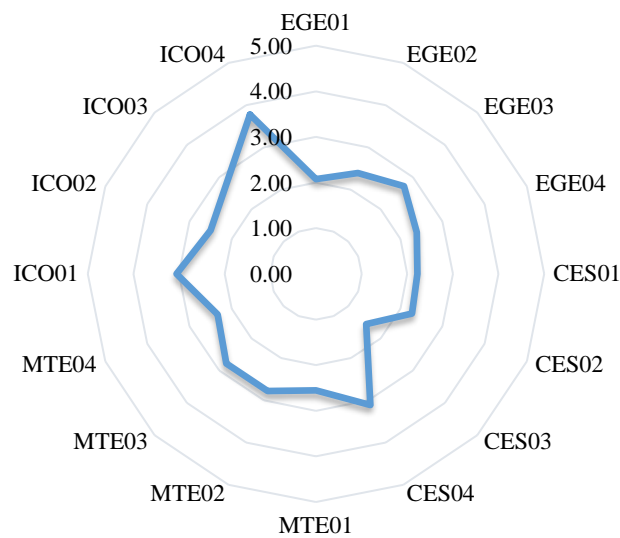
The values represented in table 2.2 were collected on the basis of the questionnaire applied in the TES and were used to generate the radar graph representation (Table 2.3). In column three the average corresponds to each of the factors and column four shows the average for each dimension.

Table 2.3 Values and averages for dimensions and factors according to the responses collected from the questionnaires

Dimension	Factor	Average	Average size
Strategy and management	EGE01	2.07	2.39
	EGE02	2.39	
	EGE03	2.72	
	EGE04	2.39	
Culture and structure	CES01	2.22	2.29
	CES02	2.28	
	CES03	1.56	
	CES04	3.11	
Market and technologies	MTE01	2.56	2.61
	MTE02	2.78	
	MTE03	2.78	
	MTE04	2.33	
Individual skills	ICO01	3.06	3.02
	ICO02	2.50	
	ICO03	2.78	
	ICO04	3.78	

Source: Own elaboration

Figure 2.2 shows the radar graph originating from table 2.3 This radar graph of the TES shows the visual representation of the results of the perception of the critical factors for the commercialisation of technologies. The ideal state would be when the perception of the variables shows a value close to 5 (Strongly Agree), because it would reflect that these variables meet the requirements for technology commercialisation. In this case we linked four dimensions and each dimension contains four variables that indicate the ideal performance of the organisation to perform technology commercialisation. The trend showing the respondents' perception of the variables corresponding to each of the dimensions indicates that only three variables were rated as "agree": CES04 Structure and encouragement of entrepreneurship (Dimension Culture and Structure), the variable ICO01 Reputation and quality of scientific output, and the variable ICO04 Problem-solving competence (Dimension Individual Competences). The perception of the variable CES03 Structure for technology development corresponding to the Culture and Structure Dimension is that there is insufficient support for technological development.

Figure 2.2 Radar chart of the TES

Source: Own elaboration

2.5 Data analysis and discussion

Analysing the overall average of dimensions, the dimension "Culture and Structure" has the lowest score, while the dimension "Individual Competences" has the highest score. The Culture and Structure dimension includes the set of ideas, values, behaviours and concepts shared by the members of the institution, in addition to considering the relevance of teaching entrepreneurship, as well as the mechanisms and instruments to provide support for the development of entrepreneurship. The result obtained here indicates that it is necessary to strengthen strategies to manage technological support services and generate awareness to develop a solid structure that serves as a basis for the development of technologies that meet the needs of the environment to help generate value and innovations.

The Individual Competences dimension involves the coordination and motivation of people to develop and implement techniques and knowledge that can be applied to solve real problems in the environment. In this institution, the factor with the highest score is problem-solving competence, which may refer to the fact that technologies are developed with a focus on problem solving.

In general, it is necessary to generate strategies to strengthen each of the four dimensions and their respective variables.

2.6 Conclusions

The main objective of the work presented here was the application of a Framework radar of critical success factors for the commercialisation of technologies in public universities, which was initially applied in Brazilian public universities.

The scientific motivation originated from the intention to apply the model (framework-radar) in a higher education institution in order to contribute to the improvement of technology commercialisation and innovation processes and thus achieve greater efficiency and effectiveness in the context of such institutions.

The data analysis allowed to show the perception of the respondents on the four dimensions and the sixteen variables of the model with the scores given to each of them, the radar map provides a graphical view of the collected answers, showing a picture in which it is possible to follow up processes that can help to improve and adapt procedures that support decision making.

Through the data resulting from the application of the model, the institution can focus on specific aspects to improve and develop capacities to commercialise technologies.

A limitation of this study is the relatively small number of responses collected. Therefore, it is intended to carry out more applications of the model to institutions of this type, such as the other three institutions that are part of the programme for strengthening the academy-industry relationship in the State of Mexico. As a suggestion for future research, it is proposed to carry out comparative analyses between public and private institutions.

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