# The Technology Transfer University Capability: A Case Study From the Triple Helix Perspective

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**Abstract:** The role of universities as innovation agents has received recently considerable attention in academia. As such, this interest is important wherein university, besides the education and research, also can contribute to the economic and social development of society through the generation of innovations. Accordingly, it is important to assess their innovation capability. Even though the current perspective considers the innovation capability of a university thanks to the number of patents produced, from a Schumpeterian perspective, innovation occurs only one invention is commercialized. Based on this perspective, this article introduces a set of indicators to assess the innovation capability of universities, with a focus on the composition of assignees of a patent from the lens of triple helix theory. There are presented three types of indicators to measure the capability of a university to create and license its patents: general; based on the composition of assignees according to the triple helix (university, government, and industry/society); and according to the combination between the composition of patent assignees and the knowledge area. These indicators are validated through a case study in a Brazilian university through a documental analysis. There were analyzed data from 775 patents deposited and licensing agreements of a Brazilian university, ranging from 2011 to 2021. As an empirical result, this research revealed considerable differences in the number of patents deposited and licensed thanks to the type of the patent assignees, as well as their knowledge area. As a theoretical contribution, the framework of assessment of the patents introduced in this article seems to be a useful tool for analyzing the current innovation capability of a university, serving as a starting point to investigate its causes. As a practical implication, the framework introduced in this article can be readily used to assess the innovation capability of universities individually or comparatively.

**Keywords:** technology-transfer, diffusion of technologies, university-industry, patents, licensing, innovation.

## 1. Introduction

Besides their mission of education and research, universities have incorporated the generation and diffusion of technologies to contribute to social and economic development (Daraio, Bonaccorsi and Simar, 2015). In this context, the elaboration of innovation performance indicators can be useful to universities to measure and improve their performance (Chen, Wang and Yang, 2009). There is a rich literature of models to assess university performance in the global aspects (Daraio, Bonaccorsi and Simar, 2015; Herberholz and Wigger, 2021), as well as those focused on innovation efficiency (Kalapouti et al., 2017; Chen and Shu, 2021; Luo, 2021).

A promising branch of research on university efficiency is to develop studies on the capability of universities to generate innovations (Herberholz and Wigger, 2021). Currently, the innovation capability of universities is considered in terms of the number of patents deposited and, not necessarily, patents effectively licensed to market agents. From a Schumpeterian perspective, innovation only takes place when an invention is commercialized (Nelson, 2009). Based on this opportunity of contributing to the literature, this article introduces a set of indicators to assess the innovation capability of universities, with a focus on the composition of assignees of a patent from the lens of triple helix theory. There are presented three types of indicators to measure the capability of a university to create and license the patent from three levels of scope: general, based on the composition of assignees considering the types of agents of the triple helix (university, government, and industry/society); and the combination between the composition of assignees based on the triple helix and the knowledge area of the patent. These indicators are validated through a case study in a Brazilian university through a documental analysis. They are addressed data from 775 patents deposited and licensing agreements of a Brazilian university, ranging from 2011 to 2021.

The set of indicators shows good adherence and usefulness as an instrument to measure and analyze the innovation capability of universities.

Besides this first section, this article is organized in the following way. Section 2 presents a literature review. Section 3 details the methodology, the research object, and the data analysis. Sections 4 and 5 present, respectively, the results obtained and the discussion based on the literature. Finally, Section 6 presents the conclusions and offers suggestions for future research.

## 2. Literature review

### 2.1 Patenting and licensing in the context of university-industry technology transfer from the triple helix perspective

From a Schumpeterian perspective, there is a difference between invention and innovation. An invention is the creation of something new, resulting in new products and processes or improvements to existing ones. In this context, the patent is an institutional mechanism to safeguard the rights of the intellectual property of inventors (Nelson, 2009). Accordingly, when an invention is effectively commercialized, it becomes an innovation (Schumpeter, 1982). The licensing of patented inventions is one of the main channels for transferring technology from the university to the market (Siegel et al., 2004).

The advent of Boyh-Dole law in USA stimulated the government of different countries to incentive universities in the creation and transfer of innovations to society (Mowery et al., 2001). In Brazil, this tendency manifested as the innovation law that instituted technology transfer offices in public universities (Brito and Fausto, 2015; Soares, Vitale Torkomian and Nagano, 2020) and strengthened science parks (Silva et al., 2020; Leite et al., 2022). Even with the implementation of various methods and techniques that support technological innovation (Fernandes, Reis and Serio, 2017; Araújo, Reis and Morais, 2021; Reis, Fernandes and Armellini, 2021; Reis et al., 2021), in Brazil, licensing rates are still low, as in other developing countries (Dos Santos and Torkomian, 2013). This scenario demonstrates the importance of establishing effective performance indicators capable of measuring the efficiency of technology performance of universities.

The interaction between universities and other agents for economic and social development can be explained through the concept of the triple helix (Etzkowitz, 1984; Leydesdorff and Etzkowitz, 1996; Etzkowitz and Leydesdorff, 2000), presenting the relationship between universities, government, and industry for the innovation promotion. Economic and social development occurs through the co-creation of knowledge and technology through this conjoint relation and their transference to society (Ranga and Etzkowitz, 2013; Ryan, Geoghegan and Hilliard, 2018; Perumal, Sreekumaran Nair and Unnikrishnan, 2020). In this context, the cooperation between industry and academic agents can extend the innovation capability of the first and improve their innovation performance (Ryan, Geoghegan and Hilliard, 2018). A form of measuring the performance of triple helix interactions is to assess the patents generated by academic agents and industry (Jovanović et al., 2022). Some recent studies show that triple helix interactions improve the capability of innovation ecosystems in producing science and innovation and augment investments in research activities (Zhang, Chen and Fu, 2019; Chang, Chen and Teng, 2021). In addition to the triple helix perspective, recent studies also consider various types of agents that can interact with the development of national innovation systems. For example, inspired by the triple helix concept Xue and Gao (2022) present the concept of the quadruple helix that, in addition to the agents of academy, industry and government, present civil society agents that are also important actors in the innovation process.

### 2.2 Assessment of performance of universities

With the purpose of measuring the efficiency of technology transfer at the university, Anderson, Daim and Lavoie (2007) used data envelopment analysis (DEA) as a productivity assessment tool. With this same objective, Secundo, De Beer and Passiante (2016) developed a maturity model based on non-monetary indicators. Through a normative approach Resende, Gibson and Jarrett (2013) propose a qualitative analysis tool for technology transfer offices to improve their efficiency, wherein they suggested 271 best practices and 43 facilitators of technology transfer. Also, in this context Aragonés-Beltrán, Poveda-Bautista and Jiménez-Sáez (2017) proposed a qualitative approach to assess their performance by analyzing the compatibility between activities carried out and the fulfilment of the established objectives of the university.

Currently, the measurement of technology diffusion in the university environment considers the diffusion of knowledge over time about a single technology (Nelson, 2009) or can compare the diffusion of different technologies (Clayton, Lanahan and Nelson, 2022).

## 3. Method

Due to the high level of depth in the analysis of the research object and its relationship with agents in its surroundings, this study can be classified as an in-depth case study (Yin, 2018). It is a case study about the capability of a Brazilian university in generating and transferring patented technologies to markets. Data were collected from public documents of this university, which is among the five public universities in the country that have the highest number of patents deposited (Brito and Fausto, 2015). Through two data sources, the list of patents deposited by the university from 2011 to 2021, accessed in the Brazilian office of industrial property (Instituto Nacional de Propriedade Industrial – INPI), and the list of patents licensed by this university, it was possible to calculate the value of the six indicators proposed in this article. As a method to verify possible differences between the deposit and licensing of patents, it was used triple helix terminology to classify the patents according to the type of assignees, that is, university, government, industry/society. Also, to permit further analysis, each patent was classified according to the knowledge area, wherein it was identified thirteen academic departments in the researched university, namely: Agricultural Sciences Institute, Architecture School, Biological Sciences Institute, Dentistry Faculty, Engineering School, Faculty of Medicine, Fine Arts School, Institute of Exact Sciences, Nursing School, Pharmacy Faculty, Physical Education, Physiotherapy and Occupational Therapy School, and Veterinary School. Table 1 presents a synthesis of the patents deposited by the university and used in this study, considering the adequation of its information.

**Table 1**: Data about the patents used in the research from 2011 to 2021

| | Licensed patents | Deposited patents |
|---|---|---|
| Founded patents | 24 | 853 |
| Eliminated patents | 2 | 78 |
| Total used | 22 | 775 |

The application of the lens of triple helix focused on its types of agents, university, industry and government, permitted to identify differences in the performance in the rates of licencing and time of transfer of patented technologies for the studied university to society. Even though it is a single case, the conceptual framework presented in this article can be replicated in other universities, which is a theoretical contribution of case studies (Einsenhardt, 1989).

## 4. Results

The elaboration of the indicators is based on the concept of the triple helix proposed by Etzkowitz (1984), using the quantities of patented inventions and licensing contracts. There are proposed two basic types of indicators. One type is related to the rates of technology transfer, which consists of the division of the total of licensed patents, by the total of deposited patents, according to a specific criterion (general; by knowledge area; or by the composition of assignees of the patent) in each period. The second type of indicator is related to the average time between the deposit and the licensing of patents, also according to the three criteria presented above. Figure 1 shows the set of proposed indicators detailed in Table 2.

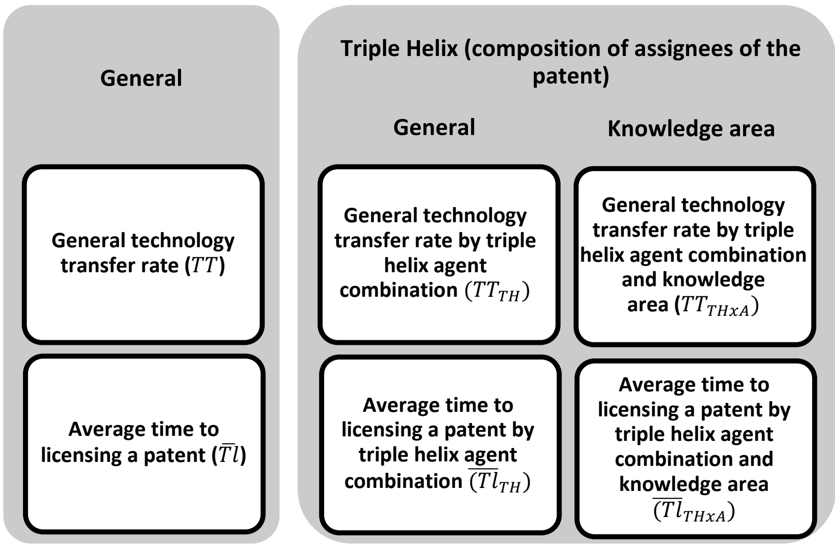



**Figure 1:** Set of indicators

**Table 2:** Performance indicators

| Indicator | | | Formula | Description |
|---|---|---|---|---|
| General performance indicators | | General technology transfer rate ($TT$) | $TT=\frac{LP}{DP}$ | $LP$ - number of licensed patents<br>$DP$ - number of deposited patents |
| General performance indicators | | Average time to licensing a patent ($\overline{T}l$) | $\overline{T}l=\frac{\sum_{i=1}^{n}(Ly-Dy)}{n}$ | $Ly$ - the year of the licensing<br>$Dy$ - the year of patent deposit |
| Triple Helix | General by triple helix agent combination | General technology transfer rate by triple helix agent combination ($TT_{TH}$) | $TT_{TH}=\frac{LP_{TH}}{DP_{TH}}$ | $LP_{TH}$ – licensing number by triple helix agent combination<br>$DP_{TH}$ – number of patents filed by triple helix agent combination type |
| Triple Helix | General by triple helix agent combination | Average time to licensing a patent by triple helix agent combination ($\overline{T}l_{TH}$) | $\overline{T}l_{TH}=\frac{\sum_{i=1}^{n}(Ly_{TH}-Dy_{TH})}{n}$ | $Ly_{TH}$ - the year of the licensing by triple helix agent combination<br>$Dy_{TH}$ - the year of the patent deposit by triple helix agent combination |
| Triple Helix | Indicators by knowledge area | General technology transfer rate by triple helix agent combination and knowledge area ($TT_{THxA}$) | $TT_{THxA}=\frac{LP_{THx\,A}}{DP_{THx\,A}}$ | $LP_{THx\,A}$ – licensing number by triple helix agent combination and knowledge area<br>$DP_{THx\,A}$ – number of patents filed by triple helix agent combination type and knowledge area |
| Triple Helix | Indicators by knowledge area | Average time to licensing a patent by triple helix agent combination and knowledge area ($\overline{T}l_{THxA}$) | $\overline{T}l_{THxA}=\frac{\sum_{i=1}^{n}(Ly_{THxA}-Dy_{TH\,xA})}{n}$ | $Ly_{THxA}$ - the year of the licensing by triple helix agent combination and knowledge area<br>$Dy_{TH\,xA}$ - the year of the patent deposit by triple helix agent combination and knowledge area |

## 4.1 Innovation capability of the researched university in a general perspective

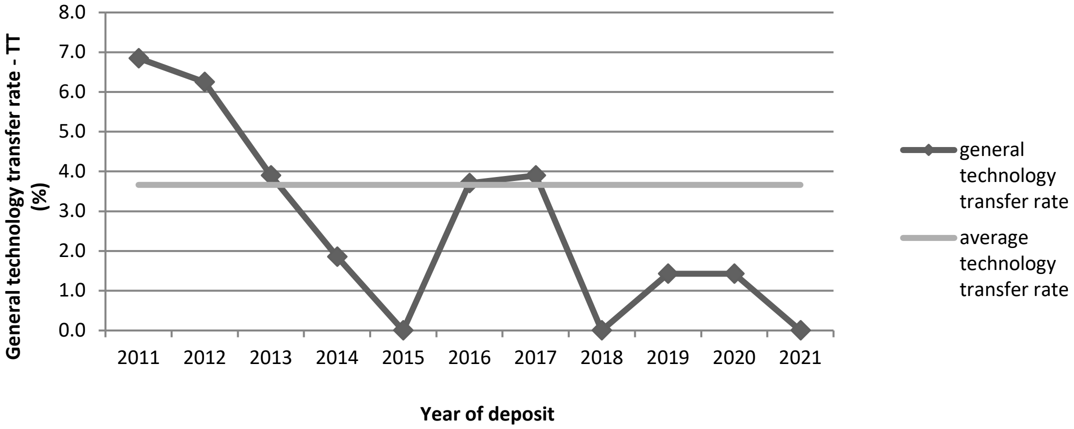
Table 3 presents the results of the general performance indicators, general technology transfer rate ($TT$) and average time to licensing a patent ($\overline{T}l$). The data is organized by year. In general, one can observe a low tax on licensing of patents by the researched university. Also, there is considerable variability in the percentages of patents licensed over the years, ranging from 1.4% in 2019 and 2020 to 6.8% in 2011, maintaining a low percentage of licensing (in the order of 2.8%, being 22 licensing in a total of 775 deposited patents). Likewise, there is considerable variability in the average time from patent depositing to licensing.

**Table 3**: General performance indicators

| Year | Licensed patents | Deposited patents | $TT$ (%) | $\overline{T}l$ (years) |
|---|---|---|---|---|
| 2011 | 5 | 73 | 6.8 | 3.0 |
| 2012 | 5 | 80 | 6.3 | 4.8 |
| 2013 | 3 | 77 | 3.9 | 2.3 |
| 2014 | 1 | 54 | 1.9 | 1.0 |
| 2015 | - | 67 | - | - |
| 2016 | 3 | 81 | 3.7 | 1.7 |
| 2017 | 3 | 77 | 3.9 | 2.0 |
| 2018 | - | 66 | - | - |
| 2019 | 1 | 70 | 1.4 | 2.0 |

| Year | Licensed patents | Deposited patents | $TT$ (%) | $\bar{T}l$ (years) |
|---|---|---|---|---|
| 2020 | 1 | 70 | 1.4 | 1.0 |
| 2021 | - | 60 | - | - |

Based on Table 3, Graph 1 shows the general technology transfer rate in each year of the analyzed period and the general average rate of technology transfer.




**Graph 1**: Variation in the general rate of technology transfer during the analyzed period

## 4.2 Innovation capability of the university based on triple helix perspective

This section presents the general performance of the researched university according to the types of patent assignees to the triple helix typology (Section 4.2.1) and according to a combination of triple helix agents and the knowledge area of patents (Section 4.2.2).

### *4.2.1 Innovation capability according to the type of patents' assignees*

Considering the performance of the university in licensing patents according to the different types of triple

helix agents, one can observe a considerable difference, whereas patents assigned by the university and society and the university, industry and government have the highest rates. In the case of society, it was observed the creation of the patent through the partnership between the university and individuals. This high rate of licensing in these two types of patents is probably because patents created in cooperation with industry and individuals are based on some specific and perceived demand that motivated the creation of the patent, which after its deposit has facilitated its licensing to market agents.

**Table 4:** Technology transfer rate and time by type of triple helix agent

| Triple Helix Agent | $TT_{TH}$ | $\bar{T}l_{TH}$ |
|---|---|---|
| University | 0.024 | 2.367 |
| University and government | 0.015 | 3.250 |
| University and industry | 0.025 | 1.500 |
| University, industry and government | 0.118 | 4.000 |
| University and society | 0.667 | 2.000 |
| Average | 0.170 | 2.623 |

With respect to the time of licensing a patent to the market, the highest time is for patents assigned by university, industry and government. This probably occurs due to the number of agents and the diversity of interests involved in the negotiation of the rights of a patent that can delay its licensing. In contrast, patents assigned by university and industry, and university and society are those with the shortest transfer time. This situation takes place probably to the fact that as well as in the case of the licensing rate, the innovations contained in these patents are developed due to previous demands identified, wherein the patent is generated with the focus of solving a clear problem.

#### *4.2.2 Innovation capability of the university from triple helix and knowledge area perspectives*

With the purpose of further exploration of patent and licensing data, the information of assignees of patents was crossed with their knowledge field. Owing to the patents created uniquely by the university, only three departments, Exact Sciences Institute, Biological Science Institute, and Engineering School, have licensed patents, whereas the first, in addition to the best licensing rate, also has the best time to license. Considering the patents generated by the university and government, only the Medicine Faculty and the Institute of Biological Sciences have licensed patents. This is probably because in their majority, the technologies contained in these patents are destined to solve demands related to health issues and, in this case, receive the support of the government with the purpose of solving social demands.

Only the Institute of Exact Sciences, which comprehends disciplines such as physics and chemistry, has patents with the participation of university and industry licensed to markets. In fact, in this institute, there are some research groups maintaining cooperation with industrial agents with the purpose of developed technologies for specific demands. But curiously, the Engineering School, which traditionally encompasses disciplines directed to solve market problems, does not demonstrate the capability of transferring patents generated with the participation of university and industry to markets.

**Table 5:** Technology transfer rate and time by type of triple helix agent and knowledge area

| University Department | University | | University and government | | University and industry | | University, industry and government | | University and society | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Rate | Time (years) | Rate | Time (years) | Rate | Time (years) | Rate | Time (years) | Rate | Time (years) |
| Medicine Faculty | 0.0 | - | 25.0 | 3.0 | 0.0 | - | 0.0 | - | 0.0 | - |
| Exact Sciences Institute | 3.6 | 1.5 | 0.0 | - | 4.9 | 1.5 | 0.0 | - | 0.0 | - |
| Engineering School | 1.7 | 2.0 | 0.0 | - | 0.0 | - | 0.0 | - | 0.0 | - |
| Biological Sciences Institute | 3.5 | 3.6 | 2.6 | 3.5 | 0.0 | - | 0.0 | - | 0.0 | - |
| Dentistry Faculty | 0.0 | - | 0.0 | - | 0.0 | - | 0.0 | - | 0.0 | - |
| Fine Arts School | 0.0 | - | 0.0 | - | 0.0 | - | 0.0 | - | 0.0 | - |
| Veterinary School | 0.0 | - | 0.0 | - | 0.0 | - | 50.0 | 4.0 | 0.0 | - |
| Nursing School | 0.0 | - | 0.0 | - | 0.0 | - | 0.0 | - | 0.0 | - |
| Agricultural Sciences Institute | 0.0 | - | 0.0 | - | 0.0 | - | 0.0 | - | 0.0 | - |
| Architecture School | 0.0 | - | 0.0 | - | 0.0 | - | 0.0 | - | 0.0 | - |
| Physical Education, Physiotherapy and Occupational Therapy School | 0.0 | - | 0.0 | - | 0.0 | - | 0.0 | - | 100.0 | 2.0 |
| Farmacy Faculty | 0.0 | - | 0.0 | - | 0.0 | - | 0.0 | - | 0.0 | - |

Only the veterinary school presented licensed patents created through the interaction among the university, industry, and government. This probably occurs due to the interest of the government in supporting the agribusiness sector and the interest of this economic sector in adopting technologies to increase its productivity. However, these patents also present the biggest average time to licensing patents compared with the other modalities and other knowledge areas. This can happen due to the number of assignees and the diversity of interests of agents involved in the property rights of patents. Lastly, this research observed patents created through the partnership between the university and individuals, classified here as civil society. The fact that the totality of patents of this modality was licensed with a low time of transference (2 years) indicates probably a demand perceived in society that motivated the development of a patented invention (100% of deposited patents by Physical Education, Physiotherapy and Occupational Therapy School have been licensed).

## 5. Discussion

This article assumes the perspective of the social role of the university as the creator of innovative technologies and their transfer to markets (Anderson, Daim and Lavoie, 2007; Kalapouti et al., 2017). As such, the patent is an important instrument of technology transfer between university and industry, which is in line with the literature (e.g., Siegel et al., 2004). The set of indicators proposed reinforces the current view about the importance of measuring the capability of universities in developing and transferring technologies to society (Chen et al., 2009; Chen and Shu, 2021). From an empirical perspective, this study confirms the findings of Santos and Torkomian (2013) that verified a low patent licensing rate of the universities. In this study, in a universe of 775 patents deposited between 2011 and 2021, only 22 were licensed (2.8% of the total).

This article presents an alternative view in relation to some studies about university performance indicators (Daraio, Bonaccorsi and Simar, 2015; Kalapouti et al., 2017; Chen and Shu, 2021; Herberholz and Wigger, 2021; Luo, 2021) by presenting a proposal of performance indicators to measure the technological transfer of technologies by universities, including three perspectives, general, by the type of triple helix agents, and through the combination of the type of triple helix agent and knowledge area. Thanks to the combination of the ideal types of the triple helix (Etzkowitz, 1984; Leydesdorff and Etzkowitz, 1996; Etzkowitz and Leydesdorff, 2000) and the knowledge area of a patent, this study permits the assessment of the capability of a university to transfer patented technologies to society. Additionally, this set of indicators opens the opportunity for the university to investigate the probable motives due to possible differences in the performance of these indicators, thanks to the criteria for the classification of patents.

## 6. Conclusion

This article adds to the literature concerning previous research that deals with the measurement of the performance of universities that are based on global performance measurement (Chen, Wang and Yang, 2009; Daraio, Bonaccorsi and Simar, 2015) or focused on their innovative capacity (Anderson, Daim and Lavoie, 2007; Resende, Gibson and Jarrett, 2013; Aragonés-Beltrán, Poveda-Bautista and Jiménez-Sáez, 2017). Its contribution is to propose a set of indicators for measuring the current capability of a university to generate patents and license them to market agents. Particularly, the assessment of the performance of patents according to the types of assignees based on the triple helix and the combination of the types of assignees and the knowledge area of a patent can be a powerful instrument to investigate the causes of eventual differences in the rate and licensing time. From a practical perspective, this set of indicators can be adopted to assess the innovation capability of universities in current ranking models. Once the innovative capability of a university is currently evaluated based only on the number of patents deposited, the indicators proposed in this article assume the Schumpeterian perspective of innovation, which considers innovation when inventions are commercialized in markets (Schumpeter, 1982). Further, they also can be used by universities to assess their performance and investigate the causes of eventual differences in licensing and time rates, with the purpose of developing more efficient policies for the creation of patents and licensing.

As an article limitation, although under capitalism, most innovations manifest themselves as something that can be commercialized, this view has its limitations. This is because there may be innovations that benefit society without necessarily being directly commercialized, for example, several innovations in the health context. This type of innovation can be termed no-market innovation and can be investigated in future studies in the university context.

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