UNIVERSIDADE ESTADUAL DO OESTE DO PARANÁ
PROGRAMA DE PÓS-GRADUAÇÃO EM ADMINISTRAÇÃO
MESTRADO PROFISSIONAL

WESTERN PARANÁ STATE UNIVERSITY
PROFESSIONAL MASTER'S IN ADMINISTRATION

RELAÇÃO ENTRE FATORES INDIVIDUAIS E CONTEXTUAIS COM A GERAÇÃO DE PATENTES EM INSTITUIÇÕES DE ENSINO SUPERIOR

RELATION AMONG CONTEXTUAL FACTORS AND PATENT PRODUCTION IN HIGHER EDUCATION INSTITUTIONS

[TRADUÇÃO INGLESA]

TAISLAINE DE MOURA

CASCAVEL/PR

2022

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Dissertation presented in partial fulfilment of the requirements for the degree of **Master of Science in Administration** in the Department of Administration, Western Paraná State University.
Dissertation supervisor: Dr. Marcelo Roger Meneghatti;
Dissertation Co-supervisor: Dr. Ivano Ribeiro.

Dissertação apresentada ao Programa de Pós-Graduação em Administração (Ppgadm) – Mestrado Profissional da Universidade Estadual do Oeste do Paraná, como requisito parcial para obtenção do grau de **Mestre em Administração**.
Orientador: Dr. Marcelo Roger Meneghatti
Coorientador: Dr. Ivano Ribeiro

CASCAVEL/PR

2022

International Cataloging-in-Publication Data
UNIOESTE Library System

Moura, Taíslaine de.
Relation among contextual factors and patent production in higher education institutions / Taíslaine de Moura; Marcelo Roger Meneghatti; Ivano Ribeiro [Translation of Ana Maria Martins A. Vasconcelos]. 2023.
51 f.

Dissertation (Master's of Degree – Campus of Cascavel) – Western Paraná State University, Center for Applied Social Sciences, Graduate Program in Administration, 2023

[English version of: Relação entre fatores individuais e contextuais com a geração de patentes em instituições de ensino superior]

1. Strategy. 2. Innovation. 3. Intellectual property. I. Meneghatti, Marcelo Roger. II.Ribeiro, Ivano. III. Vasconcelos, Ana Maria Martins A. IV.Title.

unioeste
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PARANÁ
GOVERNO DO ESTADO

TAÍSLAINE DE MOURA

Relação entre fatores individuais e contextuais com a geração de patentes em instituições de ensino superior

Dissertação apresentada ao Programa de Pós-Graduação em Administração em cumprimento parcial aos requisitos para obtenção do título de Mestra em Administração, área de concentração Competitividade e Sustentabilidade, linha de pesquisa Estratégia e Competitividade, APROVADO(A) pela seguinte banca examinadora:

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Cascavel, 21 de dezembro de 2022

I present this research to my mother, Chelaine, my husband, Igor, my sister, Crislaine, my aunt, Sheila, and my grandmother, Irma, for all the support they have given me. To my grandfather, Antônio (*in memoriam*), who left without seeing my achievement.

ACKNOWLEDGMENTS

I would like to thank the Western Paraná State University – UNIOESTE, which since 2016 has been my second home, from undergraduate to master's degree. Thank you for the opportunity to help on my studies; to prepare me to be a researcher and professional. Firstly, I'm a PIBIC scholarship holder (2017) and then a technical scholarship holder at ITH - Innovation and Technology Hub' (2020) and at Extension Pro-rectory (2021 and 2022). I have a lot to thank everyone who was part of "my Unioeste family";

To the Graduate Program in Administration, to the professors and collaborators for all the support and teaching;

To my advisor and co-advisor, Professor Dr. Marcelo and professor Dr. Ivano, for the whole attention given to me, and all patience. You are a source of inspiration and admiration; I am very grateful that our paths have crossed;

To my mother, Chelaine, who, even far away, has always supported my studies, and who read and helped me along this dissertation, supported me in moments of despair, and to be always cheering for me;

To my stepfather, Reginaldo, who encourages me to thrive and study more, and who gave me a notebook, so that I could attend the online classes and prepare all my master demands;

To my husband, Igor, who never let me give up, and to believe that I am able of anything, and always encouraged me;

To my family, sister, grandmother and aunt who, for everything I needed, were always available, and cheer up of every winning of mine, I love you;

To my colleagues at PROEX, who supported me on difficult days many times;

Finally, I would like to thank everyone who has been involved with me in this process.

RESUMO

Moura, Taíslaine. (2022). Relação entre fatores individuais e contextuais com a geração de patentes em instituições de ensino superior (Dissertação). Programa de Pós-Graduação em Administração (PPGA), Universidade Estadual do Oeste do Paraná – UNIOESTE, Cascavel, PR, Brasil.

Essa dissertação teve como objetivo analisar a relação entre os fatores individuais e contextuais com a geração de patentes em Instituições de Ensino Superior (IES). Teve como amostras os autores de patentes das IES brasileiras, que mais depositaram patentes no INPI (Instituto Nacional de Propriedade Industrial) desde 2018 até 2020. Com a busca na literatura específica na área, quatro hipóteses de pesquisa foram formuladas e relacionadas com as variáveis: 'bolsa estudantil', 'tempo de existência do NIT – Núcleo de Inovação e Tecnologia', 'tempo de formação do pesquisador' e 'titulação do pesquisador'. Optou-se pelo método quantitativo e, para a coleta de dados, foram investigados os relatórios do INPI e o Currículo *Lattes* dos autores das patentes. Os dados foram analisados por meio de modelos de Regressão Linear Múltipla. Os principais resultados apontam que ser bolsista, o tempo de formação e a titulação dos pesquisadores têm relação positiva com o número de patentes depositadas das IES. Logo, é possível afirmar que ter o financiamento de bolsa, seja de iniciação científica, de pesquisa, de produtividade ou outras, impacta positivamente no número de depósitos de patentes das IES. Em conjunto com o tempo de formação e a titulação dos pesquisadores apresentou resultado positivo com o número de depósitos de patentes. Por fim, este estudo contribuiu para identificar os fatores que estão ligados ao número de patentes depositadas pelas IES. E contribui diretamente com as IES e a gestão dos NITs, para fomentar a produção e o registro de patentes.

Palavras-chave: Estratégia; Inovação; Propriedade Intelectual;

ABSTRACT

Moura, Taíslaine. (2022). *Relationship among contextual factors and patent production in higher education institutions* (Dissertation). Post-Graduate Program in Management (PPGA), State University of Western Paraná – UNIOESTE, Cascavel, PR, Brazil.

This master's dissertation aims at analyzing the relation among individual and contextual factors due to patents application in Higher Education Institutions (HEI). The samples were based on researchers from Brazilian HEIs, who most applied patents at NIIP (National Institute of Industrial Property) from 2018 to 2020. According to its literature research, it was possible to table four hypotheses, related to the following variables: 'student's scholarship', 'period of existence of an ITH - Innovation and Technology Hub', 'researcher's graduation time' and 'researcher's degree'. It is quantitative research and to obtain the studied data collection, NIIP reports, and the Curriculum *Lattes* of authors who applied for patents were investigated. Data were analyzed using multiple Linear Regression models. The main results highlighted that scholarship researchers, their qualification time and title have shown a positive relation with the number of patents applied at HEIs. So, it is assumed that that having scholarship funding, whether for scientific initiation, research, productivity or others, has a positive impact on the number of patents applied by Brazilian HEIs. Thus, the association between qualification time and researchers' degree has recorded a positive answer when related to the number of applied patents. This study contributed to identify which factors are associated to the number of patents applied by HEIs. It has also contributed to the HEIs and ITH management to encourage the production and application of patents.

Keywords: Strategy; Innovation; Intellectual property;

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LIST OF ABBREVIATIONS AND ACRONYMS

BNDES - National Bank for Economic and Social Development

Capes - Coordination for the Improvement of Higher Education Personnel

CNPq - National Council for Scientific and Technological Development

HEIs - Higher Education Institutions

INPI - National Institute of Industrial Property

IP - Invention of Patent

ITH – Innovation and Technology Hub

ME - Microenterprise

MEI - Individual Microentrepreneur

NIH - National Institutes of Health

NIT - Technological Innovation Hubs

R&D - Research and Development

RSF - Research Support Foundations

S&T - Science and Technology

STI - Scientific and Technological Institutions

TTO - Technology Transfer Offices

UEPB - State University of Paraíba

UFAL - Federal University of Alagoas

UFCG - Federal University of Campina Grande

UFMG - Federal University of Minas Gerais

UFPB - Federal University of Paraíba

UFPE Federal University of Pernambuco

UFPR - Federal University of Paraná

UFS - Federal University of Sergipe

UFSC - Federal University of Santa Catarina

UM - Utility Model

UNICAMP - State University of Campinas

UNIOESTE - Western Paraná State University

USA – The United States of America

USP - University of São Paulo

SUMMARY

1 INTRODUCTION

The environment of Higher Education Institutions (HEIs) is highly innovative, as evidenced by the INPI (National Institute of Industrial Property) ranking of 2020. It can be observed that nine out of the top ten positions are universities (INPI, 2020). Therefore, HEI managers should pay attention on how to evolve in terms of 'patent production'. The area related to Intellectual Property has a direct connection to the country's development and was an element that contributed to the reconstruction of countries after the Second World War. It was one of the main reasons for boosting the technological and economic development of European countries (Biagiotti, 2014). Intellectual Property has already been the subject of much discussion and improvement in the political sphere, the consequences of which are some changes to the Laws, for example, there were changes to decree nº. 9,283/2018, which regulates the New Legal Framework for Science, Technology, and Innovation (Law nº. 13,243/2016), based on Law nº. 10,973/2004 and Constitutional Amendment nº. 85/2015.

These Laws have brought incentive to HEI inventors to produce innovations as a result of their researches, "by supporting research and technology transfer. Therefore, it is necessary to develop intellectual property aligned with the market" (Oliveira Jr. & Almeida, p. 139, 2019). In 2020, decree nº. 10,534 was created on October, 28th, 2020, to improve and make easy some points of the Innovation Law. The National Innovation Policy was officially established in it, which established its governance model - the Innovation Chamber (MCTI, 2020).

HEIs are at the top of the patent application podium in Brazil (INPI, 2020). According to the INPI ranking in 2019, the top universities are: Federal University of Paraíba - UFPB in first place, Federal University of Campina Grande - UFCG in second place, Federal University of Minas Gerais - UFMG in third place, State University of Campinas - UNICAMP in fifth place, and University of São Paulo - USP in sixth place (INPI, 2020). It can be observed that universities are large producers of knowledge and innovation, which shows the relevance of HEIs in the context of innovation and technology production, when compared to elements related to innovation and intellectual property (Ortiz, 2019).

It is important to have guidelines for decision-making within organizations, but the structures of HEIs are complex, generating several pressures and many forms of power that act on the decision of Intellectual Property (Schuch Jr, Abreu, Bobsi, & Leão, 2005). Individuals have typically constructed mental models within their knowledge, and most stimuli are internal, set up in each person's mind (Simon, 1979; Ribeiro, 2015). Both for HEIs and for researchers,

the decision to innovate is a challenge because it generates diversity of ideas (Pisano, 2019), in addition to the difficulty of finding the right place and a scarcity of qualified personnel in the studied area (Prazeres & Lopes, 2021). The lack of funding, or if inventiveness has been really relevant to society, we can say that these are also difficulties that were found out by HEIs (Pires, Rita, & Pires, 2020).

Research can be sponsored by HEIs partner companies, but scientific productivity and research development in Brazil are usually funded by development entities, and research scholarships are the main form of direct financial support for researchers. The most accessed funding entities are: the Coordination for the Improvement of Higher Education Personnel (Capes), the National Council for Scientific and Technological Development (CNPq), and the Foundations for Support of Research (FAPs) (Vasconcelos et al., 2021). Scholarships intended for graduate students/researchers, and even if they are not directly associated to innovation, they can generate patents, since the volume of Research and Development (R&D) is linked to the number of patents applied with the development of its economic growth (Rainatto, Silva, Silva, & Andrade, 2021).

This research will address individual and contextual factors, which are organizational environment, the university and the Innovation Center or Agency, innovation funding by agreements with companies, scholarship funding, or investments in programs that support new patents production by the state. Individual factors of inventors are related to the researcher's educational level and if he/she has a research or production scholarship. It is worth noting that patents are the most important indicator of innovation and help the country's development (Biagiotti, 2014).

1.1 RESEARCH PROBLEM

Innovation has been gaining greater proportions and, according to the ranking of Brazilian patent applications at INPI, Higher Education Institutions (HEIs) have the highest number of patent applications in Brazil, thus, making them the largest holders of Intellectual Property in Brazil (INPI, 2020). There is still a need to identify what can cause institutional scientific and technological development aiming at promoting patent production, technology transfer, and interaction networks (Souza, Souza, Lima, & Araújo, 2021). New technologies developed by HEIs are analyzed from several perspectives to be applied in the market (Oliveira Jr & Almeida, 2019). However, it is necessary to uncover what lies behind these patent applications. Researchers Almendra, Bezerra, Magalhães, and Bortoli (2021) have indicated some important points, such as the study area, the region that submits the most patent

applications, and the inventor's field of study. The authors point out that a more comprehensive analysis of the number of patents is needed to address these points.

Innovation and Technology Hubs (ITH) are studied regarding their background, development, structure and play an active role in managing and producing innovation in HEIs. The work performed by some ITHs is in the process of structuring HEIs in their relationships with society (Castro & Souza, 2012). HEIs should prioritize their internal policies regarding Intellectual Property, seeking to protect the knowledge produced in the academic environment and promote the transfer of technology produced to other sectors (Diláscio et al., 2021). Innovation has been driving the discussion on the importance of Intellectual Property management, as it is directly associated to the technological and economic development of countries (Oliveira Jr. & Almeida, 2019). Even with an ITH already installed, it is not always synonymous of consolidated innovation within HEIs (Freitas & Lago, 2019).

Higher Education Institutions (HEIs) have gained prominence in the development of new technologies since the Law promulgation nº 10.973/2004, Art. 1, which provides "measures to encourage innovation, and scientific and technological research in the productive environment, to obtain some technological capacity" (Brasil, 2004). Researchers who are benefited by these incentives, usually intermediated by ITH, find it easier to produce innovations (Santos, Menezes, Serafini & Silva, 2018). However, lack of financial support is a barrier to patent development (Oliveira, 2017).

Brazil has an innovative potential with significant scientific production, a significant number of researchers, and considerable investment, but it leaves something to be desired, when it comes to transforming these same researches into technological innovation and, consequently, patent application (Ortiz & Lobato, 2019). In Brazil, after the Innovation Law, academic patenting has received more attention, but it is still necessary for more studies to be developed, particularly to unite the interests of researchers, the university, and potential interested parties in these technologies (Oliveira, 2017).

Thus, the gaps found are: the need to find out what causes institutional scientific and technological development, with the aim of generating more patents (Souza et al., 2021); to reveal what factors are important regarding patent applications (Almendra et al., 2021); and that more research is needed to unite the interests of researchers and HEIs, to increase academic patenting (Oliveira, 2017), thus, constructing the research problem.

1.1.1 Research Question

What are the relationships among individual and contextual factors and the generation of patents in Higher Education Institutions?

1.2 OBJECTIVES

1.2.1 General

To analyze the relationships among individual and contextual factors and the generation of patents in Higher Education Institutions.

1.2.2 Specific

a) To examine the main individual and contextual factors, in the organizational environment, related to innovation in the literature;
b) To identify the Higher Education Institutions (HEIs) that have applied the most number of patents from 2018 to 2020;
c) To identify the individual and contextual factors of the studied HEIs with the number of applied patents.

1.3 JUSTIFICATION AND CONTRIBUTION OF TECHNICAL PRODUCTION

This research aims at understanding factors related to generating patents in HEIs. Thus, it may be possible to understand where Institutions can improve this production. This can bring benefits to society with new products and services, generating external and internal economic development, being aware of how much intellectual development can be achieved based on this research. This study includes innovation, patents, decision-making, innovation environment, among others, and therefore, it is necessary researching and analyzing such variables.

Knowing what happens in universities to create an invention and what can facilitate the patenting of that invention can provide relevant data for the market, society, and the academic community. Oliveira Jr. and Almeida (2019) state that it is important to learn about intellectual property management and technological innovation as they are reasons for the economic development. However, the knowledge generated in universities represents a source of information and new technologies creation.

According to the emergence or strengthening of Technology Transfer Offices (TTOs), since the Innovation Law (Brasil, 2004), Scientific and Technological Institutions (STIs) have had a structure capable of managing and protecting their intangible assets and developing the competence to transfer them to the market. A well-structured STI brings facilities to the innovation process, since the research carried out by it can result in literary trials, and can also generate industrial creations, computer programs, etc. Therefore, every scientific and technological intellectual activity has the potential to generate knowledge, which can imply technological innovations that are susceptible to protection (Santos, Toledo & Lotufo, 2009). This study is justified by the fact that innovation has the power of economic development (Ortiz & Lobato, 2019), as well as bringing benefits to society with new products and services. Innovation and patent generation have covered relevant topics to be discussed, such as innovation culture, R&D, Higher Education Institutions, Technology Transfer Offices, and technology funding agents in Brazil. As Souza et al. (2021) state about innovation, there is also a need to find those who induce scientific and technological development.

1.4 DISSERTATION STRUCTURE

This study begins with the approach of theoretical and practical references on the researched subject. The main themes are "Generation of Patents in Higher Education Institutions", "Characteristics of Innovative Environments," "Technology Transfer Offices and Innovation Agencies," and "Behavior and Sociodemographic Characteristics of Innovators," in order to understand the general topic "Innovation within Higher Education Institutions." Then, the research methodology is explained based on the research design, data collection procedures, and data analysis procedures. The next steps are the analysis and interpretation of results, as well as the application of the methodology and its interpretations. Subsequently, the results discussion is presented, followed by the conclusion of the research. To conclude the structure of this research, the references of the documents used throughout this study are presented.

2 THEORICAL REFERENCES

2.1 GENERATION OF PATENTS IN HIGHER EDUCATION INSTITUTIONS

Innovation is directly associated to the interrelation between university and industry. This relationship is essential for the innovation development in the country; therefore, it is important that innovations developed by universities can reach society. Institutes of Science and Technology (ICT) are entities of public administration whose mission is to develop and execute scientific or technological research activities. ICTs are characterized by being an innovative environment with an innovative culture. To better manage innovations, Innovation and Technology Hubs (ITH) were created under the requirement of the 2004 Innovation Law (Roczanski, 2016). Patent applications from Brazilian universities are mostly for new products, meaning they are Patents of Invention.

There are two kinds of patent applications: Patents of Invention (PI) and Patents of Utility Model (UM) (Almendra et al., 2021). PI is a creation that results from a new solution, and may refer to industrial products such as compounds, compositions, objects, devices and others, or to industrial activities such as processes, methods, and others. Meanwhile, the UM patent is classified as an object of practical use or a part thereof. It must be three-dimensional and presents a new way or inventive arrangement that improves its functional use or manufacture. While the Patent of Invention aims to protect a technical creation, the Patent of Utility Model aims to protect a technical effect that seeks to improve the object's use (INPI, 2012).

According to the INPI Activities Report of 2018, the applicant profile consists of 42% individuals, 28% Higher Education and Research Institutions and Government, 18% Medium and Large Companies, and 11% Small Companies Individual Microentrepreneur (MEI), and Microenterprise (ME). In Utility Model patents, 66% are from individuals, and Higher Education and Research Institutions and Government hold only 3% of applications (INPI, 2022). The involvement of Higher Education Institutions (HEIs) and the productive sector are growing, and this connection stimulates academic research aimed at the productive sector and an increase in patent applications (Oliveira, 2017).

According to Moraes et al. (2014), when there is cooperation among HEIs and companies based on agreements, patent development is successful. In Industrial and Innovation Policy, funding is a recurring item, resulting in the creation of new instruments and review of the legal framework (Santana et al., 2019). Not only in Brazil but also in China, the increase in

patent applications occurred due to greater investments in research (Chen & Zhang, 2018). Similarly, in The United States of America (USA), the largest funder of research is the National Institutes of Health (NIH), where the bio-pharmaceutical industry is a sector of the economy where innovations are considered extremely important for health, productivity, and well-being. It was found out that NIH funding stimulates patents' development by the private sector, with a $10 million investment in research leading to a net increase of 2.7 patents (Azoulay, Zivin, Li & Sampat, 2019).

In Brazil, there are several ways of obtaining resources. One of them is the National Bank for Economic and Social Development (BNDES - NBESD), while regional and state public banks stand out for financing production and infrastructure of the country, for companies and public organizations (Araújo & Cintra, 2011). Support for science and technology is provided by funding agencies such as the Coordination for the Improvement of Higher Education Personnel (Capes), at the federal level, and Research Support Foundations (FAP) at the state level, in addition to CNPq and FINEP (Santana et al., 2019).

Federal public financing for innovation has been mainly carried out by tax incentives from the Ministry of Science, Technology, and Innovations (MSTI) and financing operations from FINEP and BNDES. These institutions have been expanding their activities simultaneously, both in terms of subsidized resources and beneficiary companies (Santana et al., 2019). As a funding entity, CNPq has the role of approving calls for proposals, aiming at advancing research and knowledge production in Higher Education Institutions (HEIs). It provides public funding for technological innovations, which take part of the preparation of public policies, as well as promotes qualification and technical support to professors who can get funding (Vasconcelos et al., 2021).

The Federal University of Santa Catarina - UFSC - has the support of partner companies and the government to promote research and patent production in Santa Catarina. These affiliated companies operate in the construction and maintenance of laboratories, while the government encourages scientific and technological research with scholarships and financing, by the Foundation for Research Support of Santa Catarina (FAPESC) and FINEP. The Higher Education and Research Institutions of Santa Catarina are taking their place in patent production. And the trend is to increase researchers' interest in invention and application at INPI to protect their inventions (Moraes et al., 2014).

It was found out that the Brazilian region with the highest number of patent applications is the Southeast. This can be justified by the concentration of financial investments in that region and by the fact that it has the most prominent institutions in the country, such as the

Federal University of Minas Gerais - UFMG, the State University of Campinas - UNICAMP, and the University of São Paulo - USP (Moraes et al., 2014).

Researchers benefited by these financing programs find it easier to produce innovations. An example is the CNPq productivity scholarship holders, associated to the Federal University of Sergipe - UFS, who, with the interaction of these actors, indicate a potential increase in technological assets, thus, increasing the possibility of investment by funding agencies (Santos, Menezes, Serafini & Silva, 2018). Many researchers have this kind of support, such as researchers from UFPE and UFPR. 65% of them stated that they are productivity scholarship holders, and another 50% were or are CNPq productivity scholarship holders. This fact is in line with CNPq's practical intentions, which are to encourage academic patenting by highly productive researchers from Brazilian HEIs.

For some researchers, the lack of financial support is a barrier to patent development in HEIs, reaffirming that these institutions' financial incentives are essential for patent production (Oliveira, 2017). Thus, according to Moraes et al. (2014), Oliveira (2017), Santana et al. (2019), and Azoulay et al. (2018), when there is some financial support from scholarships for researchers, it is received as an incentive for innovation. The primary form of direct support for researchers is the granting of scholarships. Thus, we can create the first hypothesis:

Hypothesis 1: The researcher has or had a scholarship is positively related to the number of patent applied from HEIs.

2.2 CHARACTERISTICS OF INNOVATIVE ENVIRONMENTS

The Triple Helix (TH) is the interaction among university, industry, and government (Etzkowitz & Leydesdorff, 1995). An entrepreneurial university that practices this interaction becomes the central point of innovation theory and practice (Etzkowitz, 2013). In this scenario, new approaches have arisen, which includes the society named as Quadruple Helix (QH), and when it is associated with the environment, it is created the Quintuple Helix (5H). Thus, all these environments are associated to the production of innovation (Carayannis & Campbell, 2009; Carayannis & Campbell, 2011). As this innovation policy is recent, as well as the country's cultural change process; and considering that the economy is based on commodities, Triple Helix interactions still have a reduced effect on the Brazilian economy (Roczanski, 2016).

An organization is considered innovative when it presents the following aspects: "perception of innovation results by the organization"; "culture content"; "involvement of

individuals with innovation activities"; "perception of results by society" and "characteristics and actions of leadership" (Bruno-Faria & Fonseca, 2015). With these perceptions of innovative culture, it becomes easier to obtain support for science and technology. Thus, funding agencies can select how to foster innovation (Oliveira, 2017). Another way to identify if an organization is innovative is by patent applications. Patent registration is increasingly used as a statistic for invention activities' results. The number of patents from an organization or a country reflects its technological potential (Paulo, 2019).

The balance for the culture of innovation is in having pleasant and favorable behaviors, which can be understood as stricter and inhibitory behaviors. It is necessary to have an environment with psychological safety, so that it is easy to express oneself without fear of retaliation, thus, this expression can be exercised fully. In companies where there is a collaborative culture, environments are usually innovative, even if they focus on individual responsibility. Culturally, it is known that when organizations are even, they can generate diversity of ideas (Pisano, 2019). Even if the company is concerned with developing an innovative culture, a high turnover among employees undermines the initiative to create a culture that fosters innovative behavior (Pugas, Ferreira, Herrero & Patah 2017).

We know that human behavior can be influenced in several ways, in fast changing environments that have new information in a short period of time, making decision-making unpredictable (Eisenhardt & Martin, 2000). Similarly, environments can influence human behavior to enable effective decision-making (Bourgeois & Eisenhardt, 1988). However, hostile environments increase the degree to which managers' strategic decisions are erratic (Mitchell, Shepherd & Sharfman, 2011). Therefore, it is relevant for organizational values to be translated into desired behaviors. Risk-taking, open innovation, flexibility, quality communication, valuing employees, all of these indicators is evident in innovative environments. Similarly, companies' values influence organizational rules, and for this cycle to flow continuously, it is important to have a way of reward and recognition for creative work (Gomes et al., 2017).

Lavrado et al. (2020) bring the main enabling characteristics to innovation cultures, which can be of the hard or soft skill type, with behavioral and relationship characteristics named soft skills and procedural characteristics named hard skills. It is normal to question whether the organizational profile of each company will influence whether the organization is more adept at implementing artifacts and products. One of these enabling characteristics is the 'resource', whose characteristic is a hard skill of an innovative environment.

Technology centers or offices must find the right measures (e.g., monetary or non-monetary incentives, or provide information at internal events) and offer them to the right group of scientists (e.g., departments) at the right time. This is challenging because scientists' decision to publish or patent depends on various factors, including individual preferences, perceived normative social pressure from colleagues, level of information received through word-of-mouth communication or informative events, and previous firsthand experience (Backs, Günther, & Stummer, 2019).

2.3 CENTERS AND INNOVATION AGENCIES

Federal Law n. 10,973 of December 2004, regulated and implemented on October 11, 2005, amended in 2016, and regulated by Executive Decree 9,283/2018 on February 7, 2018 (Brazil, 2018), defines innovation promotion in Brazil, and creates the bridge between education and business. Some Technology Transfer Offices (TTOs) are still being created and adapted, and from the decree. They begin to expand their structures and innovation policies in ICTs, thus, the management of Intellectual Property also undergoes changes (Pires, Santa Rita & Pires, 2020). The main focus of the Innovation Law is to safeguard ICTs knowledge, and even so, the number of ICTs that do not have a request for IP protection is still high (Paranhos, Cataldo & Pinto, 2018). The Innovation Law required ICTs to create Innovation Centers, so they can manage the institutional innovation policy generated within these institutions (Pires, Santa Rita & Pires, 2020). In the USA, Technology Transfer Offices (TTO) commonly have the option to outsource technology transfer activity to an independent party. These models are recommended when Institutions have considerable intellectual property portfolios. The Universities of Bern and Zurich jointly created a subsidiary and non-profit TTO to facilitate research for public benefit, develop close ties with industry, and increase institutional revenue (Chakroun, 2017).

Some Higher Education Institutions (HEIs) and other Science and Technology (S&T) Institutes already had TTOs ten years before the legislation required them. The State University of Campinas (UNICAMP), Federal University of Rio de Janeiro (UFRJ), Federal University of São Paulo (USP), Federal University of Rio Grande do Sul (UFRGS), and Federal University of Minas Gerais (UFMG) already had offices or other technology sectors to assist their researchers (Castro & Souza, 2012). To boost innovation, HEIs articulate Teaching, Research, and Extension for technology development and its transfer. According to this way, it is possible to apply the knowledge generated in business segment or in consolidation of technology-based

business incubators (Pires, Gomes, Santos & Quintella, 2015). The Innovation Centers were created to strengthen ties among Institutions and Industry to disseminate the results of knowledge generated within ICTs (Prazeres & Lopes, 2021).

According to the 2018 FORMICT Annual Report - Form for Information on Intellectual Property Policy of Scientific, Technological and Innovation Institutions in Brazil -, there are 169 public institutions and 51 private institutions that already have ITH implemented. While 28 public institutions and 22 private ones are still in the implementation process (MCTIC, 2019). The essential activities of ITHs that have had the greatest implementation are: monitoring the processing of requests and maintenance of IP titles; ensuring the maintenance of the institutional policy to promote IP protection; giving opinions on the convenience and promoting the protection of creations developed within the institution (MCTIC, 2019).

Each ITH has its own policies and regulations, all based on the Innovation Law. For the ITH of the Western Paraná State University - UNIOESTE -, its activities are related to: creating, researching and developing new technologies; mediating technology transfer; promoting technical and scientific cooperation between UNIOESTE and the community; providing assistance in computerization programs; developing software and information systems, promoting and participating in programs for the training of human resources and technological development (UNIOESTE, 2021).

The university has a Technological Innovation Center, but this does not always result in innovation being implemented and consolidated, as it is necessary to have strategic actions in different fields of activity. It is necessary for the ITH to be aligned with the institution and the agencies involved, from researchers and the institution's legal counsel to market companies and the government (Freitas & Lago, 2019). Many technologies under development are still in the initial stages and require time and resources to be transformed into innovation. Companies can finance them, and the ITH acts both as an intermediary between the company and the university and to protect ICT knowledge, as well as in the technology transfer process (Lotufo, 2009).

Companies also need innovations to increase competitiveness and for some companies to stand out in the market. One way to achieve this is to use the knowledge of ICTs (Lucena & Sproesser, 2015). The ability to transmit technology is also important, approximated by the lifetime of an intermediation structure, such as technology transfer offices (TTO) at universities (Barra & Zotti, 2018).

One of the difficulties for academic patenting is the lack of support for IES and the need for more structured ITHs to support researchers, especially with employees who are experts in marketing activities, monitoring and evaluating technology potential (Pires & Quintella, 2015).

Scientific production in Brazil stands out when it comes to the number of scientific papers published by researchers, and with the implementation of policies that increase the capacity to turn science into technology and innovation, this does not happen when it comes to patents (Pires, Gomes, Santos & Quintella, 2015).

ITHs need to be more strategic, that is, they need activities focused on academic entrepreneurship and commercial negotiations, as they play the role of interveners/representatives between the university and industry (Oliveira, 2017). Not all institutions have technological innovation centers, which makes it difficult for them to be included as patent applicants (Moraes, Pinto, Dutra & Matias, 2014). It can be seen that even with ITH implemented, patent applications may not occur for many reasons (Freitas & Lago, 2019). Nevertheless, a well-structured ITH provides support to researchers for patent applications (Oliveira, 2017), where this agency or center is important to transfer technology (Barra & Zotti, 2018).

Some Technology Transfer Offices (TTOs) or Innovation Agencies are still under construction and adaptation, so, it is possible to perceive that they are at different levels of organization and development. Some of them show difficulties in management and performance, that is, this includes everything - from their team organization to the difficulty in dealing with the market. This occurs due to their innovation system and the internal and external bureaucracy of their institutions (Freitas & Lago, 2019). An example is the TTO of the State University of Paraíba (UEPB), Inovatec, created in 2009, which struggles to manage the eight (8) campuses, even with the support of the Advisory Council in other campuses.

These adversities are commonly found in other TTOs in Brazil, as well as the scarcity of specialized human resources or bureaucracy to develop their activities. Despite these difficulties, Inovatec was highlighted as one of the main patent applicants in 2020, alongside INPI (Prazeres & Lopes, 2021). The TTO of the Federal University of Alagoas (UFAL) was created in 2008 to adapt to the Innovation Law of 2004. Before that, the university did not have any kind of innovation or intellectual property management. UFAL's main difficulty is the lack of resources to hire personnel (Pires, Rita, & Pires, 2020). Some HEIs had innovation agencies before the Innovation Law, and some created an agency after the law (Pires, Santa Rita & Pires, 2020).

The 'creation time' factor proves to be positive for a better structuring of the TTOs. One of the differences among TTOs is the number of people working in them. While a newly created TTO has two employees, the oldest has from 62 to 80 employees (Paranhos, Cataldo & Pinto, 2018). Four US University Technology Transfer Offices (UTTO) were analyzed, and it was

possible to observe that the oldest has a clear advantage in terms of relationship with stakeholders interested in licensing or transferring technology, focusing on business strategy, marketing, and several other categories (York & Ahn, 2012).

In five ITHs of Federal Institutions of Education, Science and Technology in Minas Gerais, some comparisons were made in the most recent one, which is working for seven years. It does not have an exclusive room for its activities and organization, and has two employees: one is a graduate scholarship holder and the other has a permanent position. The record shows that, in 2018, this ITH made three patent applications. The oldest of these ITHs has been working for nine years. It also does not have an exclusive space, but it has five employees to develop activities. Three of them are graduate scholarship holders and two are permanent employees. This ITH made eight patent applications (Silva, Ribeiro, & Barros, 2019). Therefore, it is possible to perceive that there are differences among ITHs, based on their operating time. The oldest ITHs are more structured, and better integrated into the ICT. They also have more personnel, and better training (Paranhos, Cataldo & Pinto, 2018). Thus, it is possible to establish the second hypothesis.

Hypothesis 2: The Innovation Center/Agency lifetime is positively related to the number of patent applications of IES.

2.4 BEHAVIOR AND SOCIO-DEMOGRAPHIC CHARACTERISTICS OF INNOVATORS

Innovation lies in the decision, and when it has to decide between two or more options, there are influences that interfere in the decision-making process because one seems more interesting than the other. It is up to each individual to keep in their conscious the information of each problem that has already been solved, so that they can use this knowledge to solve equivalent problems or create new solutions that solve this adversity (Ribeiro, 2015).

According to Bezerra et al. (2022), the entrepreneur is someone who aims to be better, with a conscious purpose, who makes the decision to become better through the study and development of human abilities. There is still a limited understanding of the entrepreneurs' concept and their contributions. The interests of professors' and students' researchers should meet with potential entrepreneurs to produce innovation. The university should encourage the meeting between them and on behavioral contents that stimulate these entrepreneurial competencies (Bezerra, Melo, Rego, & Fernandes Júnior, 2022).

When the decision comes to patent, sectorial behavior is explained by being associated with industrial solutions or use, that is, it is a protection strategy for innovation (Santos, Hoffmann, Jara & Coral, 2014). Brazilian university education is still tied to the traditional university model, which prioritizes training focused on so-called basic research, which values and prioritizes the transfer of scientific knowledge to the company. This characteristic may explain the low relationship among higher education levels of partners and innovative companies. This may also justify the full-time employment of most Brazilian researchers in universities and not in companies, as occurs in technologically consolidated countries (Guimarães & Azambuja, 2018).

There is confirmation that different profiles between male and female young innovators bring opportunities to reach segments in an unusual way (Monteiro & Veiga, 2009). Regarding innovators' gender, a survey carried out in different countries, with entrepreneurs aged 18 to 64, sought to discover three indicators: a) the percentage of women involved in innovative activities among those surveyed ones, b) men's rate engaged in innovative activities among those surveyed ones, and c) the ratio between the indicators' values that describe innovative activity of male and female entrepreneurs. Based on this, it was identified that the average rate of entrepreneur women engaged in innovation activities was almost 25.3%. The value of the same indicator for men was almost 26.5%. That is, on average, in the countries under analysis, women entrepreneurs were 1.2% less likely to innovate than male entrepreneurs. In twenty-four countries, the indicators' values for women were higher than for men. In eight countries, the indicators' values for women and men were the same (Pinkovetskaia, 2021).

It is noted that in the 20th century there was an increase in women's education, which led to an increase in female presence in S&T job market (Azevedo & Abrantes, 2021). In general, companies with innovative development have entrepreneurial directors capable of reading the opportunities in their environment and taking advantage of them. Typically, these are people under 40 years old, with previous experience in the sector and higher education (Pitre-Redondo, Hernández-Palma, & Sierra-Parodi, 2020).

For Perez, Bengoa, and Fernandes (2011), the number of applied patents is an economic indicator as it is a tool for technological information related to inventive activities and products with innovative potential. Therefore, it is a stimulating and developing mechanism for Research, Development, and Innovation activities. Most researchers who have completed a doctorate in Brazil have a post-doctorate and hold a leadership position in a research group. Additionally, they supervise graduate students, as there is little difference between researchers who supervise only master course, only doctoral, or both. Also, in general, in Brazilian public

universities, almost all researchers are also undergraduate professors (Oliveira, 2017). Pitre-Redondo, Hernández-Palma, & Sierra-Parodi (2020) observed that entrepreneurs under 40 years old have an innovation vision, even when they are young with higher education. Given these statements, it is possible to formulate the following hypothesis:

Hypothesis 3: The researcher's education level is positively related to the number of patents applied by higher education institutions.

It is possible to observe that there are differences among professionals according to their education level. Pinheiro (2012) found out that professionals with higher education show more innovative behaviors. Creativity is developed when stimulated; therefore, higher levels of education develop aptitude in creativity and innovation, thus facilitating problem-solving.

The potential to create an innovative culture is influenced by the employees' education level (Pugas, Ferreira, Herrero & Patah, 2017). Innovation activities, among which R&D and patent registration stand out, have a direct impact on organizational performance, specifically on its export capacity, especially when involving highly skilled researchers and cooperation activities with universities and research institutes (Santos, Hoffmann, Jara & Coral, 2014). According to the OECD (Organization for Economic Cooperation and Development), the education of masters and doctoral degrees has a positive effect, therefore, it is essential for research and innovation systems (OECD, 2015).

Pitre-Redondo, Hernández-Palma and Sierra-Parodi (2020) affirm that most innovative entrepreneurs have higher education. Pinheiro (2012) states that workers with higher education show more innovative behaviors, and Oliveira (2017) confirms that most researchers have a doctoral degree. Thus, we have constructed the fourth hypothesis.

Hypothesis 4: The researcher's academic degree is positively related to the number of patents applied by the HEIs.

3 METHODOLOGY AND RESEARCH TECHNIQUES

In this chapter, the methodological procedures employed in this research are presented. The section is divided as it follows: research design, data collection procedures, research variables, research's population and sample, and data analysis procedures.

3.1 RESEARCH DESIGN

This research began with a literature review, in order to find out other researches concerning the addressed topic, to identify gaps in studies and keywords. Thus, the researched papers provided a background to discuss this topic. Galvão (2011) reinforces that literature review helps a researcher to have better cognitive conditions, and avoid plagiarism, or when necessary, to reuse and replicate research in different ranges and contexts. We can observe flaws in the carried out studies, and identify resources that are relevant to construct a study with specific characteristics. It is descriptive research, as the events that occurred and occur were described regarding the discussed topic. As Manzato and Santos (2012) state, facts or variables can be observed, recorded, analyzed, and correlated in descriptive research without manipulating them. In this kind of research, it is possible to know the individual in isolation or more complex groups and communities. Descriptive research can find out the frequency with which a phenomenon occurs, its relationship and connection with others, as well as the nature and characteristics of these phenomena (Manzato & Santos, 2012).

The study was also exploratory, since based on some reports, variables of this research process were analyzed. Exploratory research aims to understand the topic to comprehend and make it easier and clearer. Thus, exploratory research aims at discovery (Munaretto, Corrêa & Cunha, 2013).

It is also classified as quantitative research because it determines if the hypotheses predicted theoretically can be supported or not. Manzato and Santos (2012) state that quantitative research is applied to measure opinions, reactions, sensations, habits, and attitudes of a sample or population that is statistically proven to represent them.

3.2 DATA COLLECTION PROCEDURES

The data collection procedures were divided into four parts: the first dealt with empirical research, where keywords and research gaps were identified. In the second part, data were collected according to the reports from universities that applied the most patents in the last four

years. The third part dealt with data collection, where data from already applied patents were collected from the university repository or via e-mail provided by the ITH of HEIs. The research began searching for papers related to innovation, and data collection was performed in April 2021.

In this phase, studies from 1945 to 2021 were selected in an attempt to include all trials related to the theme of Decision Making in University Innovation, in order to identify gaps in the study, based on the used keywords. Thus, the entire research time of the platform was chosen to search for papers. So, the Web of Science platform was chosen to select them, as it is considered as relevant in Administration area. It broadly covers the best international papers on this topic within the scope of Scientific Communication.

The search terms used were Decision Making, and within this search, the words Innovation AND University were added as topics. Only papers were selected into the categories: Management OR Business OR Information Science Library Science OR Education Educational Research OR Public Administration. The specified time frame was from 1945 to 2021. A total of 215 papers were found, and thematic classification was done through open coding based on the papers titles. The exclusion criteria used was: the subject did not refer to the studied theme (decision-making, intellectual property in universities). Out of the 215 papers found on the general theme, 69 papers were selected based on the title reading. The selected papers were analyzed according to the VOSviewer program, and it was possible to relate the most used terms for analysis. The results can be seen in Figure 01, with the terms of papers with the highest recurrent incidences.

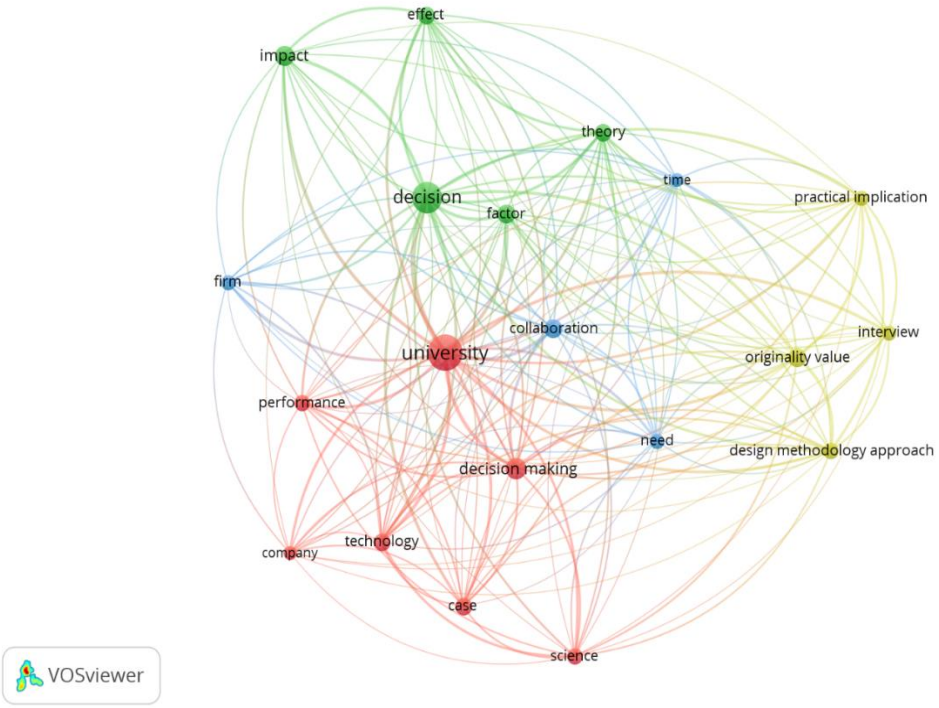

Figure 1- Terms of selected papers with the highest incidences of repetition.
Source: Survey data (2020).

We can analyze that the green cluster emphasizes the word "Decision," linking it to impact and effect and making the connection between the factor and theory. Similarly, the word "University" is emphasized in the red cluster and is linked to decision-making, technology, enterprise, performance, case, and science. The blue cluster has the words "Collaboration," "Company," "Need," and "Time," while the yellow cluster brings the terms "Practical Implication," "Interview," "Originality Value," and "Design Methodological Approach." This initial search for themes related to innovation, decision-making, and the university helped to find papers with study gaps on the related topic and also keywords that could help searching for new papers to support this research.

The second stage of data collection was to investigate the higher education institutions (HEIs) that applied the most number of patents in 2018, 2019, and 2020 on the INPI website, among their annual reports of "Ranking of Resident Applicants." This research was carried out in July 2021, and therefore, there were no data on patent applications for 2021. It was decided to search for these reports in 2018, since the latest decree to regulate the New Legal Framework for Science, Technology, and Innovation was issued on February 7, 2018, decree nº 9.283/2018. Thus, the HEIs to be investigated were selected. Figure 2 - Ranking of Resident Applicants - INPI 2018, 2019, and 2020 show the eleven (11) largest applicants for the respective years.

2020 - Invention of Patent			2019 - Invention of Patent			2018 - Invention of Patent		
ranking	Aplplicant	number	rank	applicant	number	rank	Applicant	number
1	UNIVERSIDADE FEDERAL DE CAMPINA GRANDE PB (UFCG)	96	1	UFPB	100	1	UFPB	94
2	PETRÓLEO BRASILEIRO SA (PETROBRAS)	79	2	UFCG	90	2	UFCG	82
3	UNIVERSIDADE FEDERAL DA PARAIBA (UFPB)	74	3	UNESP	88	3	UFMG	62
4	UNIVERSIDADE FEDERAL DE MINAS GERAIS (UFMG)	63	4	UFMG	61	4	PETROBRAS	54
5	UNIVERSIDADE ESTADUAL PAULISTA JULIO DE MESQUITA FILHO (UNESP)	55	5	PETROBRAS	56	5	UNICAMP	50
6	UNIVERSIDADE FEDERAL DE PERNAMBUCO (UFPE)	55	6	UNICAMP	54	6	USP	47
7	UNIVERSIDADE DE SÃO PAULO (USP)	51	7	CNH INDUSTRIAL BRASIL LTDA.	50	7	UNESP	38
8	UNIVERSIDADE ESTADUAL DE CAMPINAS (UNICAMP)	50	8	USP	45	8	UFRGS	36
9	UNIVERSIDADE FEDERAL DE PELOTAS (UFPel)	38	9	UFPE	44	9	UNIR	35
10	UNIVERSIDADE FEDERAL DE UBERLÂNDIA (UFU)	38	10	UFRGS	37	10	UFC	34
11	UNIVERSIDADE FEDERAL DO PARANA (UFPR)	38	11	UTFPR	35	11	UFPE	32

Figure 2 - Ranking of Resident Applicants - INPI 2018, 2019 and 2020.
Source: Adapted from the National Institute of Industrial Property (2021).

In Figure 2, it is possible to observe all the rankings up to the 11th place for the three years. Table 1 was elaborated with the sum of applicants from 2018, 2019, and 2020 to organize the data of the researched institutions, as well as the data of the seven HEIs that applied the most number of patents in these three years were organized in ascending order, beginning with the one that applied the least number of patents.

Table 1 - **Sum of Applicants from 2018, 2019, and 2020.**

Ranking	Applicants	Number
1	UFCG	**268**
2	UFPB	**268**
3	UFMG	**186**
4	UNESP	**181**
5	UNICAMP	**154**
6	USP	**143**
7	UFPE	**131**

Source: Survey data (2022)

Thirdly, patent repositories were searched on the ITH or Innovation Agency websites to obtain data on patent application from the selected universities. Emails were sent requesting data for universities presented in Table 1 that did not have the necessary data for research on

their website or in some way. The universities that showed their data on website or sent them via email were UFMG, UNESP, and UFCG. After that information was obtained, data were identified: each author of the patents, the studied area, title, and year. Thus, we moved on to the fourth stage, where inventors' characteristics were collected based on their *Curriculum Lattes*. The applied number of patents that each author held, the activity field, training time, training degree, and finally, whether or not the researcher was or still is a scholarship holder were obtained. The data were tabulated and analyzed using JAMOVI software, and Pearson correlation analysis, linear regression, as well as model coefficient measures were used, checking for assumptions such as Durbin-Watson test, collinearity statistics, and normality tests.

3.3 RESEARCH VARIABLES

Our dependent variable is the researchers' 'number of Patents' from the selected universities. Data were collected from the INPI reports from 2018 to 2020, by patent application title. The authors/inventors of those patents titles were observed, and it was observed that there can be several inventors for a single patent. The number of patents was also measured since each author registered on their *Curriculum Lattes*.

Four possibilities were formulated as independent variables. The first one is 'to be or has been a scholarship holder', which is related to the individual factor and was coded as a dichotomous variable: No (0) and Yes (1). This variable was measured according to the authors' *Curricula Lattes*, where it was observed if the individual was a scholarship holder or not. The following factors were considered as Yes (1): scholarships from State Foundations for Support and Promotion of Research, CNPq scholarships for research and productivity, master and doctoral scholarships, Capes scholarship, and international research scholarships.

The second variable is 'The Innovation and Technology Hub lifetime '. This variable is related to the contextual factor, and the year of ITH creation was collected from the HEIs website or the ITH itself. Thus, in order to measure in years, the current year (2022) was subtracted from the year of creation of each ITH, which resulted in the information on each Hub lifetime.

The third variable is the 'Researcher's training time'. This is an individual factor, so, to code this variable, the graduation year of each patent author was collected. Therefore, to measure these data, author's graduation year was subtracted from the current year (2022), resulting in the author's graduation year regarding his/ her. These data were collected from the *Curriculum Lattes* of each patent author from the studied HEIs.

The fourth and final variable was the 'Researcher's degree'. This variable is also related to the individual factor. Therefore, data were coded as: (1) Bachelor's degree, (2) post-graduation, (3) Master degree, (4) Doctorate, (5) Post-doctorate, which were also extracted from the inventors' *Curricula Lattes* regarding the researched patents. It was included as a control variable if the HEI was State or Federal, which were coded as (0) for State HEI and (1) for Federal HEI. These data were collected from the INPI list of HEIs with the most applicants selected for the survey. Thus, in Figure 3, the analysis model is observed.

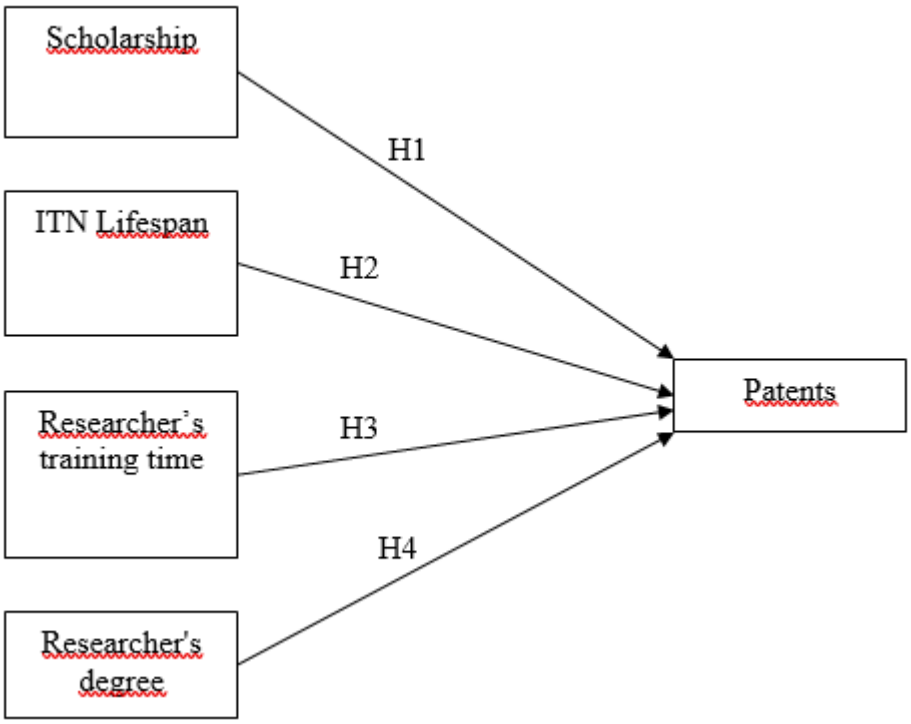

Figure 3 – Research Model.
Source: Research data

3.4 RESEARCH POPULATION AND SAMPLE

The research population for this study has been defined as researchers affiliated with the seven universities that applied the most patents in 2018, 2019, and 2020. These universities are: Federal University of Campina Grande - PB (UFCG), with 82 patents applied in 2018, 90 patents applied in 2019, and 96 patents applied in 2020, totaling 268 patents that have been applied over the three studied years; Federal University of Pernambuco (UFPB), with 94 patents applied in 2018, 100 patents applied in 2019, and 74 patents applied in 2020, totaling 268 patents that have been applied; Federal University of Minas Gerais (UFMG), with 62 patents

applied in 2018, 61 patents applied in 2019, and 63 patents applied in 2020, totaling 186 patents that have been applied; São Paulo State University (UNESP), with 38 patents applied in 2018, 88 patents applied in 2019, and 55 patents applied in 2020, totaling 181 patent that have been applied; State University of Campinas (UNICAMP) with 50 patents applied in 2018, 54 patents applied in 2019, and 50 patents applied in 2020, totaling 154 patents that have been applied; University of São Paulo (USP), with 47 patents applied in 2018, 45 patents applied in 2019, and 51 patents applied in 2020, totaling 143 patents that have been applied; and Federal University of Pernambuco (UFPE), with 32 patents applied in 2018, 44 patents applied in 2019, and 55 patents applied in 2020, totaling 131 patents that have been applied.

The chosen universities that showed the necessary data were investigated to select the samples, which were made available on institutional websites in standard text format (not image), and should contain the patent title, inventors'/authors' names, and the years patents were applied. When the absence of the mentioned data was observed, they were requested by email to the HEIs on their websites. Thus, HEIs that fulfilled the request and/or had the required data for this research on their websites were selected. Samples were produced by patents' authors according to the following HEIs: UFMG (186 patents), UNESP (181 patents), and UFCG (268 patents).

3.5 DATA ANALYSIS PROCEDURES

INPI reports from 2018 to 2020 were analyzed, and the HEIs that showed the highest numbers of patent applications were collected (Figure 2). The sum of the three years was then organized into an Excel spreadsheet (Figure 3), in ascending order by number of applications: 268 patents from Federal University of Campina Grande; 268 patents from Federal University of Paraíba; 186 patents from Federal University of Minas Gerais; 181 patents from Paulista State University; 154 patents from the State University of Campinas; 143 patents from the State University of São Paulo, and 131 patents from the Federal University of Pernambuco.

Therefore, the HEIs selected for study provided the necessary data, which were: year of patent's application, title and authors of the patent, either on website or via email. These HEIs are UFMG (via email), UNESP (via the UNESP Innovation Agency website), and UFCG (via the NITT/UFCG website). Thus, it was possible to search for the *Curriculum Lattes* of each researched author based on these data. Using a spreadsheet, the number of applied patents, years of education, education level, and if the selected author had a research scholarship and productivity data were collected. The ITH lifetime was also collected from the respective HEIs websites.

The obtained data were tabulated and applied in JAMOVI. The spreadsheet was organized as it follows: institution names - federal or state; whether or not they have an ITH; ITH lifetime; author’s patent; author's graduation year; the highest level of education; whether they were a scholarship researcher; and the number of patents.

Then, it was analyzed if the variables were related to the number of patent applied at the HEIs using Pearson's correlation, Durbin-Watson test, collinearity statistics, and normality test. The obtained data were analyzed quantitatively using multiple linear regression models, and research hypotheses were tested. Multicollinearity among independent variables was verified to meet the assumptions of linear regression models, where a maximum VIF (Variance Inflation Factor) value of 1.92 confirmed the possibility of using the regression technique. The results of all analyses are presented in the next chapter.

3.6 LIMITATIONS OF RESEARCH METHODS AND TECHNIQUES

The main limitations were related to the patent data availability, as some HEIs did not provide all the necessary information on their institution's website or only provided them in image format. Additionally, searching for patent information on the INPI website by title would be too time-consuming. Some HEIs did not provide this information when requested for several reasons, including patents under confidentiality or simply having only the previously inserted information on the website. Consequently, some HEIs were excluded from this study, resulting in a smaller sample size than what it could have been achieved.

4 ANALYSES AND INTERPRETATION OF RESULTS

The multiple linear regression model was used to analyze the obtained samples. Multiple linear regression was used to estimate the relationship among a dependent variable and two or more variables, to provide conditions to use two explanatory variables simultaneously. As in Table 2 - 'ITH lifetime' and 'Patent', 'State and Federal' and 'Patent' and so on. As in this study the 'Patent' variable was defined as dependent, it must be analyzed with each independent variable. Thus, based on Pearson's correlation, Table 2 – Correlation Matrix was prepared.

Table 2 - **Correlation Matrix**

	H2 ITH Lifetime	**State or Federal**	**H3 Researcher's graduation time**	**H4 Reseacher's title**	**H1 Scholarship**
ITH lifetime	—				
HEIs. State/ Federal	0.465***	—			
Graduation conclusion (years)	0.100	-0.103	—		
Reseacher's title	0.285***	-0.145*	0.510***	—	
Scholarship	-0.361***	-0.298***	0.261***	0.257***	—
Patent	0.131*	0.184**	0.292***	0.232***	0.212***

Note. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: Research data (2022)

Table 2 indicates the connection coefficients among the variables, and each cell in the table presents the connection between two variables. But it is possible to observe how they behave when related. As the dependent variable is 'patent', the connection with the other variables is observed, highlighted in "blue". It is possible to observe that all of them have a positive correlation and are significant.

The 'R' correlation coefficient is a statistical measure that calculates the strength of the relationship among the relative moves of those variables. While the coefficient of determination 'R^2' is a measure of adjustment, it varies between 0 and 1 and measures which fraction of variance of the dependent variable is explained by the independent ones. In Table 3 – Design Adjustment Measures, there are the correlation and determination coefficients:

Table 3 - **Model Adjustment Measures**

			Global Model Test			
Models	**R**	**R²**	**F**	**gl1**	**gl2**	**p**
1	0.560	0.314	25.6	5	280	<0.001

Source: Research data (2022).

In the 'R²' coefficient of determination, the probability parameter is seen, and the model is able to predict 31.4% of the applied number of patents variability, that is, the patent generation number is predicted in 31.4% by the variables researched here, and with p-value < 0.001, we can proceed and analyze model coefficients.

The p-value is used to determine statistical significance in a hypothesis test. In the case of the hypotheses analyzed here, the p-value determines whether or not there is a relationship among the independent variables and the number of patent applications. Table 4 – Model Coefficients shows which variables are related to the patents generation.

Table 4 - **Coefficients of Model**

Predictor	**Estimates**	**standard error**	**t**	**p**	**Standardized Estimates**
Interceptor	0.32883	0.12403	2.65	0.008	
V.C – HEIs State or Federal	0.47870	0.07231	6.62	< 0.001	0.4002
H1 – Scholarship holder	0.31897	0.06123	5.21	< 0.001	0.3006
H2 – ITH lifetime	-0.00840	0.00639	-1.31	0.190	-0.0902
H3 – Researcher's education time	0.00780	0.00234	3.33	< 0.001	0.1953
H4 – Reseacher's title	0.11004	0.03145	3.50	< 0.001	0.2362

Source: Research data (2022).

It is possible to observe that H1, H3 and H4 are dependent variables with positive correlation from p-value < 0.001. Therefore, we can consider this relationship positive, because the values presented in the column 'Standardized estimate' are positive. In the case of variable H2, p-value > 0.001, is a hypothesis that does not show a relation with the dependent variable.

In Table 4, the variable 'scholarship holder' is significant, as well as the one with the highest positive association value. Therefore, we can accept Hypothesis 1. Thus, the fact that the researcher was or is a scholarship holder is positively related to the number of applications of HEI patents. It is possible to check in Table 4 that the value in the column 'Standardized

estimate' shows that the closest it is to one (1), the greatest the association between the independent variable and the dependent variable is.

The 'researcher's education time' has a significant and positive association with the number of patents applied at the HEIs. Thus, Hypothesis 3 can be accepted, since there is a positive relationship between the researcher's education time and the number of patent applications at the HEIs.

The 'Researcher's title' has a significant and positive association with the number of applied patents. So, we can accept Hypothesis 4, since ‘the researcher's title’ is positively related to the number of patent applications at the HEIs.

The dependent variable H2, 'ITH lifetime', was not related to the number of applied patents, since the value of $p > 0.001$, highlighted in red in the table, presented a value of 0.190. Hypothesis 2 was refuted, since the 'ITH lifetime' or Innovation Agency is not related to the number of patent applications at the HEIs. The DW statistic is used to indicate whether or not there is autocorrelation in the residuals of a regression, shown in Table 5 - Durbin-Watson Test:

Table 5 - **Durbin-Watson autocorrelation test**

Autocorrelation	**DW statistics**	**p**
0.137	1.72	0.016

Source: Research data (2022).

It is possible to observe that Table 5 presents the value of the DW statistic equal to 1.72. Thus, as it is close to 2, it indicates that the data does not have autocorrelation. To meet the assumptions of the analysis, the existence of multicollinearity between the independent variables was verified, as shown in Table 6 – Collinearity statistics.

Table 6 - **Collinearity statistics**

	VIF	**Tolerance**
ITH lifetime	1.92	0.520
HEIs State or Federal	1.49	0.670
Researcher’s education time	1.41	0.712
Researcher’s title	1.86	0.538
Scholarship	1.36	0.736

	VIF	Tolerance

Source: Research data (2022).

VIF (Variance Inflation Factor) value with a maximum of 1.92 is recorded in Table 6 and confirms the possibility of using the regression technique. Normality Test is exemplified in Table 7 - Normality Test (Shapiro-Wilk) to corroborate the data.

Table 7 – **Test to Normality (Shapiro-Wilk)**

Statistics	p
0.993	0.161

Source: Research data (2022).

In Table 7, we can see that p-value > 0.05. Thus, this value indicates that the data show some normality. You can use a normal QQ plot to check this assumption by testing the dependent variable. It is therefore assumed that its data are normal. In Figure 4 – Q-Q graph, it can be observed how the residuals behave.

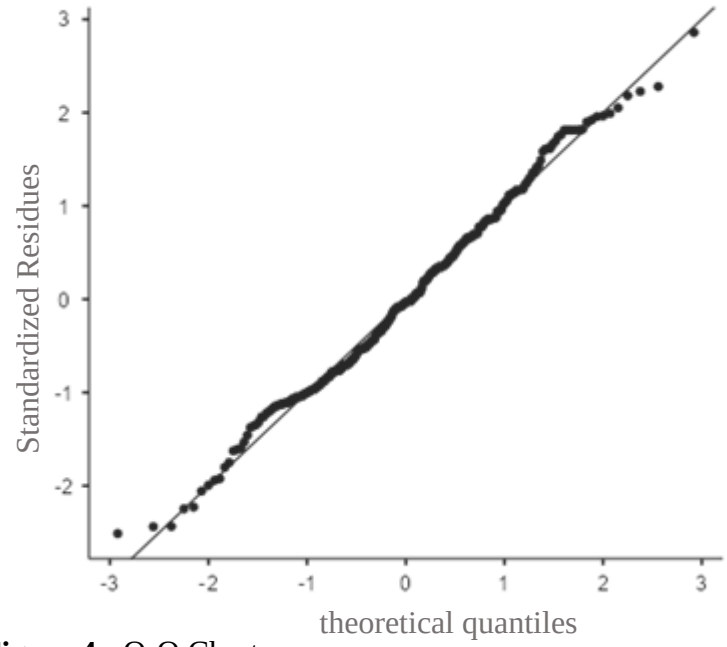

Figure 4 - Q-Q Chart
Source: Research data (2022).

The residual distribution is a visual check, but it allows us to quickly see whether the tested assumption is plausible. In Figure 4, it can be seen that the residuals are distributed approximately around the graph line, thus, indicating that the data show normal distribution. Such data are confirmed from the analysis in Table 7.

Considering the analyses presented in this chapter, it was possible to identify the connections among the studied variables, when it was determined that there was a positive correlation. The coefficient of determination was verified in the model's adjustment measure. This shows that the model predicts the variability of the number of patents applied by HEIs. In the model coefficient with the p-value, it was determined which hypotheses could be accepted or refuted. For residual analysis, DW test indicated that there was no autocorrelation. VIF verification confirmed that it is possible to use the regression technique. Finally, the Shapiro-Wilk test for normality was used, which indicated that the data showed normality, which were visibly confirmed from the Q-Q Chart. According to the assertions of these analyses, it is possible to accept or reject the hypotheses proposed in this study, and carry out the discussion of these results.

5 RESULTS DISCUSSION

This study aimed at analyzing the relations among individual and contextual factors with patents generation in Higher Education Institutions. Hypotheses were created to be accepted or refuted with the analyses made by Pearson's correlation.

Hypothesis 1, 'has been or be a scholarship holder' has a positive relation with the number of patents applied by some HEIs. It was accepted, as the variable 'scholarship holder' has a significantly positive association with the number of applied patents. Thus, as it was stated by Santos et al. (2018), the relation between scholarship funding for researchers increases the potential of technological assets, therefore, the 'scholarship holder' variable is more likely to produce innovations. Also, Azoulay et al. (2019) point out that, when there is investment in research area, there is a proven increase in patent application. For every ten million invested, it is possible to notice growth in almost three patent applications. This example is used for healthcare in the US (Azoulay, Zivin, Li & Sampat, 2019). In Brazil, there is the example of UFSC which, with the support of FAPESC and FINEP, obtains funding for scholarships. Santa Catarina HEIs have been standing out in patents production, and the scholarships offered tend to increase the researchers' interest for invention, consequently for these patents applications (Moraes et al., 2014). As in China, whose increase in applications occurred with greater investments by grants in research (Chen & Zhang, 2018).

It is possible to state that grant funding, whether for scientific initiation, research, productivity or others, has a positive impact on the number of patent applications at HEIs. Thus, the Technological Innovation Hubs or offices of HEIs can manage the Public Call to foment Innovation and their own financial resources to finance scholarships and productivity researches, whose result aimed at generating patents for HEIs. Santos et al. (2018) also presented the example of CNPq productivity scholarship holders from UFS, the investment of the development agency causes an increase in technological assets and, consequently, they receive more investment to apply patents.

HEIs associated with ITH of each one of them have the duty to mediate the meeting among researchers and prospective licensors, so that it is possible to create technological innovation with to generate patents and transfer them. According to Hypothesis 1 confirmation, HEIs need to observe how to direct resources to the ITHs and, thus, they can promote more scholarships public notices, directing these researches towards innovation.

When analyzing Hypothesis 2, 'Nucleus or Innovation Agency lifetime' is positively related to the number of applied patents', in the carried out tests, in one of them, the 'model coefficients', it was possible to observe that $p > 0.001$. Thus, there are indications that this sample is unrelated to the number of applied patents. Thus, 'Nucleus or Innovation Agency lifetime' is not positively related to the number of applied patents. This result is contrary to those obtained by Freitas and Lago (2019), who registered that it is possible to observe differences among ITHs that are still under construction or adaptation with those already implemented and with more management time. Data from this research are also contrary to those obtained by Paranhos, Cataldo and Pinto (2018), who claimed that the 'creation time' factor proves to be positive to improve ITHs structures. Thus, they are better inserted in ICTs and have better capacity for innovation management. York and Ahn (2012) state that the older the Office, the better the communication between the parties to speed up the patenting process. Moraes et al. (2014) state that the lack of ITHs hampers some HEIs to be included as patent applicants, for the management of innovation. As Hypothesis 2 has been refuted, a study gap opens up, so that innovation management can be further investigated, considering that other authors have recorded results that are different from in this study.

Hypothesis 3, 'the researcher's education time' is positively related to the number of applied patent at HEIs', is accepted so that the variable 'researcher's education lifetime' has a significant and positive association with the number of applied patents. As well as Pietre-Redondo et al. (2020) claim that experience time influences innovative growth in the organization, Oliveira (2017) reinforces those professors with more experience are involved with research and innovation. Unlike what Guimarães and Azambuja (2018) state, when they mention that researchers spend more time researching within HEIs than putting research into practice in companies.

It is clear, therefore, that the time since graduation has a positive association with the number of applied patents. Therefore, it can be said that as time passes by, the more experience the researcher can acquire, and this is confirmed by Pietre-Redondo et al. (2020) when they state that experience contributes to produce innovation and supports doubts about patenting. Backs et al. (2019) have also stated that some factors may interfere on the researcher's decision to patent, either because of the researcher's preference, or because of the level of information they receive, or because they have previous experience. By joining Hypotheses 1 and 3, it is possible to observe that the ITHs that manage scholarships and the resources distribution for innovation can allocate the coordination of these scholarships to researchers with more education lifetime.

Hypothesis 4 'the researcher's title' is positively related to the number of applied patents' and can be accepted, as it explains almost 24% of the positive variation in the number of applied patents. Just as Pinheiro (2012) stated that professionals with higher education present more innovative behavior, as they have more creativity. Pitre-Redondo et al. (2020) claim that entrepreneurs with innovative growth have higher education. Reinforcing Hypothesis 4, Santos et al. (2014) confirm that patents application has a direct impact on organizational performance in innovation, especially when it involves researchers with a high degree of education.

According to the OECD, masters' and doctors' education also has a positive effect and is fundamental for Research and Innovation Systems (OECD, 2015). ITHs must mediate to help researchers who are interested in patenting innovative research as well as to resolve doubts and provide support to those who research. Backs et al. (2019) reiterate that ITHs must find measures that best fit and offer them to the right group of researchers; and those are: monetary or non-monetary incentives, providing information at internal events or providing information that can help. Hypothesis 4 joins the other hypotheses accepted in this dissertation, as well as converges so that the studied HEIs and consequently their ITHs can observe those variables, when there is a possibility of encouraging patent applications.

6 FINAL CONSIDERATIONS

This study aimed at analyzing the relations among individual and contextual factors with patents' creations in Higher Education Institutions. When considering how HEIs are linked to innovation, it is worth mentioning that the majority of them occur in patent applications in Brazil. Therefore, it is necessary to find out what causes institutional technological development with the intention to promote patents' creations. The research focused on the factors that could be related to patents' creations. The first specific objective aimed to identify the HEIs that most applied patents from 2018 to 2020. While the second specific objective was to relate the individual and contextual factors of those HEIs surveyed with the number of applied patents, based on hypotheses to be tested.

Among the four hypotheses tested, three of them were accepted. This reinforces the indications that were found in the literature, which are: Hypothesis 1 - the author had or has a scholarship, and this causes a positive impact on the number of applied patents at HEIs, which is associated to the individual factor. Hypothesis 3 - states that the researcher's education time has a positive relation with the number of applied patent at the HEIs and Hypothesis 4 - claims that the researcher's title has a positive association with the number of applied patents at the HEIs. H3 and H4 are also associated to the individual context. Among the four suggested hypotheses, one of them was rejected, Hypothesis 2, which indicated that ITH lifetime is positively related to the number of applied patents at the HEIs. This hypothesis is associated to the contextual factor; so, it is suitable to point out that the literature has shown some studies that affirm this relation, therefore, there is a need for further investigations about it; in this way, this can be a starting point for a future study.

Based on this study, it is possible to state that having a scholarship support, whether from scientific initiation, research, productivity or other sources, causes a positive impact on the number of applied patents at HEIs. They showed a positive association with the number of applied patents plus the time since graduation and the researchers' title. The practical contribution of this study aims that HEIs and their ITHs can have a conception of how to carry out researches to their researchers. Thus, the scholarships, either by the Support Foundation or their own resources or by opening calls for partnership with companies are relevant to improve technological innovation, and actions that can increase the number of applied patents. HEI managers should be aware on how developing in terms of 'patent creation'. As the theoretical contribution reinforces some points in literature and refutes others, which can be used in future researches. As a future suggestion to be researched, it would be interesting to analyze HEI

partnerships with entrepreneurs who need innovation, and how this flow works so that more patents are created.

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