Application of the concepts of triple, quadruple and quintuple helices: a pilot project addressing the university-company relationship, innovation and entrepreneurship and the dissemination of technological knowledge

Aplicação dos conceitos de hélices triplas, quádruplas e quántuplas: um projeto piloto abordando a relação universidade-empresa, a inovação e o empreendedorismo e a disseminação do conhecimento tecnológico

Aplicación de los conceptos de hélices triples, cuádruples y quintuples: un proyecto piloto abordando la relación universidad-empresa, la innovación y el emprendimiento y la difusión del conocimiento tecnológico

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Júlia Boneti Bracht
Graduate in Production Engineering
Institution: Escola de Engenharia de Lorena da Universidade de São Paulo (USP)
Address: Lorena, São Paulo, Brasil
E-mail: juliab.bracht@usp.br

José Aprígio Carneiro Neto
PhD in Intellectual Property Science
Institution: Instituto Federal de Sergipe (IFS)
Address: Itabaiana, Sergipe, Brasil
E-mail: jose.neto@ifs.edu.br

Herlandí de Souza Andrade
PhD in Aeronautical and Mechanical Engineering by Instituto Tecnológico de Aeronáutica (ITA)
Institution: Universidade de São Paulo (USP)
Address: Lorena, São Paulo, Brasil
E-mail: herlandi@usp.br

ABSTRACT
The importance of the university-company relationship has been growing in innovation studies, as the university is a great source of information for the innovative needs of companies. The objective of this work was to discuss the university-company relationship, considering the concepts of triple, quadruple and quintuple helix as factors
that promote innovation. The methodology used was based on a systematic literature review, which presents a synthesis of the multiple articles evaluated and used. The evaluated results made it possible to highlight numerous advantages, barriers, facilitators and aspects that stimulate this relationship. Furthermore, it was possible to see how innovation, entrepreneurship and technological knowledge are important in the university-company relationship, showing that there is a need to stimulate this relationship with the aim of reducing the relationship barriers identified, as, in the current context of globalization and high-level technology development, this cooperation is of great importance for the country, positively influencing technological advances.

**Keywords:** University-Company, Innovation, Triple Helix, Technological Knowledge.

**RESUMO**

A importância do relacionamento universidade-empresa vem crescendo na área dos estudos de inovação, visto que a universidade é uma grande fonte de informações para as necessidades inovativas das empresas. O objetivo deste trabalho foi discutir o relacionamento universidade-empresa, considerando os conceitos de tripla, quádrupla e quintupla hélice como um fator fomentador de inovação. A metodologia empregada teve como base a revisão sistemática da literatura, a qual apresenta a síntese dos múltiplos artigos avaliados e utilizados. Os resultados avaliados possibilitou destacar inúmeras vantagens, barreiras, facilitadores e aspectos que estimulam essa relação. Além disso, foi possível perceber como a inovação, o empreendedorismo e o conhecimento tecnológico são importantes na relação universidade-empresa, mostrando que existe a necessidade de estimular essa relação, com o intuito de diminuir as barreiras de relacionamento identificadas, pois, no contexto atual de globalização e de desenvolvimento de tecnologia de alto nível, essa cooperação é de grande importância para o país como um todo, influenciando positivamente os avanços tecnológicos.

**Palavras-chave:** Relacionamento Universidade-Empresa, Tripla Hélice, Inovação, Empreendedorismo, Conhecimento Tecnológico.

**RESUMEN**

La importancia de la relación universidad-empresa ha ido creciendo en el área de los estudios de innovación, ya que la universidad es una gran fuente de información para las necesidades innovadoras de las empresas. El objetivo de este trabajo fue discutir la relación universidad-empresa, considerando los conceptos de triple, cuádruple y quintuple hélice como un factor promotor de la innovación. La metodología utilizada se basó en una revisión sistemática de la literatura, que presenta una síntesis de los múltiples artículos evaluados y utilizados. Los resultados evaluados permitieron resaltar numerosas ventajas, barreras, facilitadores y aspectos que incentivan esta relación. Además, se pudo ver cómo la innovación, el emprendimiento y el conocimiento tecnológico son importantes en la relación universidad-empresa, mostrando que existe la necesidad de estimular esta relación, con el objetivo de reducir las barreras de relación identificadas, como en el contexto actual. La globalización y el desarrollo tecnológico de alto nivel, esta
cooperación es de gran importancia para el país en su conjunto, influyendo positivamente en los avances tecnológicos.

**Palabras clave:** Relación Universidad-Empresa, Triple Hélice, Innovación, Emprendimiento, Conocimientos Tecnológicos.

### 1 INTRODUCTION

Nowadays, knowledge is recognized as a crucial resource, where effective management and the transfer of information between ecosystem participants play a fundamental role in the innovative process (Bacon et al., 2019). The origin of knowledge is complex, encompassing several organizational and motivational models that are noticeable in the attempt to understand the generation and transfer of this knowledge. The innovation ecosystem brings together several actors by promoting the exchange of information, involving a variety of agents, such as universities, research institutes, financiers, the government, small and medium-sized companies, as well as large corporations. In this context, organizations are increasingly interested in establishing external partnerships, driven by the goal of facilitating the exchange of knowledge across organizational boundaries (Nascimento, 2023).

Therefore, interactions between universities and companies, together with innovation, entrepreneurship and the diffusion of technological knowledge, are the basis for a country's economic growth and social development (Etzkowitz, Zhou, 2017). The importance of this relationship is accentuated when it is noted that academic research produced by universities is an important source of knowledge for industries, as they undergo constant change and seek innovation in their processes and products. According to Oliveria (2023), education represents the scenario of societies based on knowledge, and industry plays a crucial role in effective production, while the government is perceived as the creator of policies that encourage lasting interactions and exchanges.

The relationship between universities and industries has the capacity to provide cultural and social transformations in a country, in addition to stimulating its economic development. And, although these actors have different missions, interests and needs can...
be complementary, benefiting both parties. When considering several economic and political changes that have occurred in recent decades, which have transformed the university-industry relationship, it was possible to observe an increase in the rapprochement of these parties. This fact became a competitive possibility for both, despite having significant differences (Gazzetta; Kato-Cruz; Endo, 2020).

There is no doubt that innovation and technology are fundamental both for the competitiveness of industries and for local, regional and national economic development. Although companies are the center of innovation, knowledge is growing about the fact that industries cannot depend solely on their internal experiences. The relationship between a group of other agents is essential to guaranteeing business innovations. Although the university-company relationship has grown in recent years, there is still a lack of knowledge about this relationship, making it less systematically characterized (Garcia; Rapini; Cário, 2018). One of the deficiencies of the Brazilian innovation system is the lack of links between universities and companies (IEDI, 2020).

These relationships between industries and universities can be clearly understood through the triple, quadruple and quintuple helix models. The triple helix consists of an innovation model based on the relationship between government, universities and industry. These three parts of the model have respective functions and interact with each other to guarantee development through entrepreneurship and innovation. The quadruple helix model includes society, made up of product users who propose new types of innovations. The environment is included in the fivefold helix, bringing sustainable discussions.

Despite the recognition of the relevance of knowledge transfer between universities and companies, it is highlighted that this process is characterized by challenges, showing the need for a better understanding of the factors that influence its performance (DINIZ et al., 2020). Thus, this research will contribute to studies on the university-company relationship as a promoter of innovation, seeking to verify advantages, facilitators, barriers and aspects that stimulate this relationship.
In this sense, the general objective of this work was to discuss the university-company relationship, considering the concepts of triple, quadruple and quintuple helix as factors in generating and fostering innovation.

2 METHODOLOGY

The methodology used in this research was a systematic literature review, which presents the synthesis of multiple published articles, allowing the identification and evaluation of knowledge produced regarding a given topic in each area of study (Mendes; Silveira; Galvão, 2008). With the help of this review, it was possible to identify university-company relationships, with highlights in the areas of innovation, technological knowledge and entrepreneurship.

A systematic review is composed of three phases (planning, conducting, and writing reports), divided into several stages, which are: 1) Review planning (identification of the need for a systematic review; development of a review); 2) Carrying out the review (research identification; study selection; study quality assessment; data extraction and monitoring; data analysis; data synthesis); and 3) Reporting the review (preparing reports) (Kitchenham, 2004 cited by Bittencourt et al., 2016, p. 33-45).

According to Atallah and Castro (1998), this technique uses reproducible methods, choices of information and research processes, so that other authors who use this methodology reach the same conclusions. To achieve this, the systematic review was based on the following topics: database consulted; article inclusion and exclusion criteria; and review procedure (SILVA et al., 2017).

Therefore, this research is structured according to the steps presented in Figure 1.
Figure 1 - Flowchart on the systematic literature review.

In the first stage of the review, which consists of its planning and execution, different types of research methodologies were analyzed, such as action research, case studies, and field survey, among others. However, due to the global pandemic condition, it was not possible to carry out active research methodologies, therefore, a systematic review was used in this research due to the quality of its exploratory nature.

To fulfill the second stage of the flowchart and effectively carrying out the systematic review, the research was carried out on the following platforms: Scielo, CAPES Periodical Portal and Scopus. The following keywords were used to search for articles compatible with the theme proposed for the systematic review: university-company relationship, triple helix, quadruple helix, quintuple helix, entrepreneurship and technological knowledge. In this search, specific words related to the topic were used to understand each aspect of it and then immediately understand how they work together (Silva et al., 2017). After finding several articles in this search, their respective titles and
abstracts were analyzed to verify their compatibility with the theme proposed in this research.

To carry out a general analysis of the articles, firstly, the years of publication were disregarded, thus, 5,720 articles were obtained compatible with the keywords used in searches on academic websites, which, through reading the titles and abstracts, 224 were separated for reading. These selected works were read, and thus, only 23 works were included in this research, which dealt with the university-company relationship with a specific focus on the way this occurs and its importance. Furthermore, 17 studies were selected that demonstrated the concepts of triple, quadruple and quintuple helices, which explained the formation of networks in which each part of the helix should play a harmonious role in relation to the others. Finally, 8 works on innovation, entrepreneurship and technological knowledge were included, correlated with the university-company relationship (Etzkowitz; Leydesdorff, 1998; Silva et al., 2017).

Subsequently, for a more current analysis of the topic, only articles published between 2015 and 2020 were searched. As a result of this search, 2,310 works were obtained, of which 56 were selected for reading. Soon after, articles compatible with the proposed theme, with a specific focus on articles that demonstrated examples and models of university-company relationships, were analyzed and included, totaling only 14 articles for detailed observations. Finally, the main information from the articles was synthesized and worked on to write the current research. Regarding exclusion, 176 articles were disregarded as they did not explain the proposed topic clearly.

After selecting articles compatible with the theme, ensuring a quality study, and fulfilling the second part of the flowchart, Table 1 was created, to separate the articles by year of publication and related topics, assisting the research.
Table 1 - Theme, quantity and year of publication of the articles analyzed.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Amount</th>
<th>Year of publication</th>
</tr>
</thead>
<tbody>
<tr>
<td>University-company relationship</td>
<td>33</td>
<td>From 1993 to 2023</td>
</tr>
<tr>
<td>Triple, quadruple and quintuple helices</td>
<td>9</td>
<td>From 1998 to 2023</td>
</tr>
<tr>
<td>Innovation, entrepreneurship and technological knowledge</td>
<td>22</td>
<td>From 1976 to 2020</td>
</tr>
<tr>
<td>Systematic literature review</td>
<td>3</td>
<td>From 2008 to 2016</td>
</tr>
</tbody>
</table>

Source: Own authorship (2024).

Immediately afterward, an analysis and synthesis of all collected data was carried out, completing the second stage of the flowchart and, finally, a review procedure was carried out which consisted of synthesizing and describing the information from the articles read for writing the current research, fulfilling the last step of the flowchart.

To complement the systematic literature review, interviews were carried out with focus groups. The Focus Group consists of a qualitative research technique that is characterized by interviews conducted with a small homogeneous group of people. A moderator is tasked with creating a supportive environment that encourages participants to share their opinions and experiences. These discussions are centered on a specific topic of interest, with the aim of obtaining qualitative data on the subject in question (Lima; Sampaio, 2023).

In the Focus Group, three essential elements intertwine: its function as a research approach dedicated to data collection, the interaction between participants as a source of data, and the active involvement of the researcher in elaborating the topics to be discussed by the group (Vitoriano; Gasque, 2023).

Group sessions can take place in locations that encourage hospitality, privacy and social interaction. With the rise of the internet, the dissemination of Digital Information and Communication Technologies (DIT) and the growth of knowledge, combined with the ease of access to digital resources, the use of the virtual environment is becoming a growing trend for the development of research of this nature (Alves et al., 2023).

The conversations held in the Focus Group have several benefits, including serving as a tool for collecting qualitative data. During these discussions, participants develop points of view, stimulating thinking and analysis of a specific topic, which results in the generation of perspectives that will later be transformed into research data (Lima; Sampaio, 2023).
Therefore, the first step in carrying out the Focus Group was the construction of the following questions based on previous readings on the topic, to instigate group discussion:

1. What prerequisites do you consider necessary in the relationship between universities and companies?
2. How could the government facilitate the relationship between universities and companies?
3. What benefits do you see in this relationship?
4. What barriers do you see in this relationship?
5. Do you consider a relationship to be positive? In other words, does the number of benefits outweigh the barriers encountered?
6. In your opinion, what is the main role of universities, companies and government in the triple helix model?

In the second stage, the research participants were defined. Recruitment was for convenience, including participants who had contact with universities, companies and government agencies, so 10 interviewees (researchers, startup CEOs, managers of development agencies and incubators) were invited to contribute to the research.

The third stage was the development of the Focus Group, the interviews, which took place online, on a day and time previously agreed with the participants. In total, two interviews were carried out, lasting one hour and forty-five minutes each, depending on the availability of the participants.

It can be observed that the focus group technique represented an opportunity for participants to express their opinions freely, at the same time as they were guided by mediators during interactions, facilitating the sharing of experiences. Finally, the discussions were transcribed and used as a basis for the critical analysis of the literature review, where the opinions collected in the Focus Group were compared with the theoretical research carried out in this work.
3 LITERATURE REVIEW

3.1 TRIPLE, QUADRUPLE AND QUINTUPLE HELIX MODELS

According to Oliveira (2023), in the last 30 years, the debate about the role played by universities, companies, industries and government institutions, in driving innovation and economic development, has gained greater prominence. Thus, the Triple Helix theory emerged, which was initially proposed in 1996, in which it was believed in the formation of networks in which each part of the helix should play a harmonious role in relation to the others (Etzkowitz; Leydesdorff, 1998). For Etzkowitz and Zhou (2017), the Triple Helix can be defined as an innovation model in which the university, the company and the government interrelate to guarantee entrepreneurial and innovative development, based on creations in the scientific and technological environment.

In this context, it is necessary to highlight the functions and limitations of the economic, educational and political systems.

The economic system is represented by industries, companies, services and banks. This helix focuses on "economic capital" (for example: entrepreneurship, machines, products, technology, money, among others) (Nascimento, 2023). Regarding its commitments: (i) develop goods and services in an innovative way; (ii) drive change methods; and (iii) seek relationships with research centers. The company also has limitations, such as: (i) lack of preparation and planning for the development of research; and (ii) lack of capacity to invest in Research and Development (R&D) (Camboim, 2013).

The educational system is made up of academies, universities, higher education systems and schools. In this helix it is necessary to count on the support of "human capital", that is, students, teachers, scientists, researchers and academic entrepreneurs (Nascimento, 2023). Regarding responsibilities, Camboim (2013) describes: (i) producing contemporary knowledge; (ii) investigate new fields of research; (iii) research relationships between industries and government; and (iv) drive change methods. Among the limitations of the university are: (i) little connection with society and the company;
(ii) dependence on financing to carry out scientific and technological research; and (iii) little vision about workforce qualification and professional training.

The political system is also of crucial importance because it expresses the “will” towards where the state (nation-state) is heading, present or future. Therefore, this propeller has “political and legal capital” (for example: ideas, laws, plans, politicians, among others) (Nascimento, 2023). Its responsibilities include: (i) developing strategies related to innovation and knowledge; and (ii) encourage new organizations to guarantee collective development. Its limitations are: (i) little flexibility for executing projects with partners; and (ii) extensive bureaucratization (Camboim, 2013).

Lombardi (2012) presents the Quadruple Helix model, in which, in addition to the university-industry-government, the public based on media and culture is inserted. This is based, notably, on culture and the media (for example: television, internet, newspapers, among other means), which are always full of information (news, communication, social networks) (Nascimento, 2023). They have the responsibility of encouraging the production and innovation of knowledge, connecting culture, values, lifestyle, art, among others (Fiates et al., 2017; Carayannis; Campbell, 2011). The fourth helix, that is, civil society, made up of product users, has the role of proposing new types of innovation, connecting with the company, university and government (Arnkil et al., 2010).

Debates regarding sustainability led to the emergence of the Quintuple Helix, which presents the “Environment” as the fifth helix, represented by resources, plants and a variety of animals (Nascimento, 2023). This model has a provision that examines sustainable development and social ecology. This structure is aimed at a sustainable balance between the development of society and the economy (Carayannis; Campbell, 2011; Casaramona; Sapia; Soraci, 2015). The role of the fifth helix is based on reconciling new knowledge and innovations, as well as environmental challenges, expanding the perspective of socio-ecological transformations and natural environments (Grundel; Dahlstrom, 2016). According to the authors, the five-fold helix favors the establishment of a win-win condition, promoting a positive interaction between the elements of ecology, knowledge and innovation. This results in the creation of synergies between the economic, social and democratic spheres (Nascimento, 2023).
Figure 2 - Systematic triple, quadruple and quintuple helices.

Source: Adapted from Nascimento (2023).

3.2 THE UNIVERSITY-COMPANY RELATIONSHIP

Interactions between universities and companies have been gaining prominence in recent decades, including an increase in the number of studies dealing with the topic, since the university is an important source of knowledge (technology transfer) for the innovative efforts of companies. Companies, due to the increase in the complexity of products and production methods, as well as the search for new sources of knowledge by industries, that is, it is a support for business innovation activities (Garcia, 2014; Garcia; Rapini; Cário, 2018; Liboreiro, 2020).

Universities, at different levels, naturally function as repositories of essential knowledge for innovation and, therefore, are ready to apply knowledge built internally (Gomes; Perin, 2022). Given this, the university has assumed an important role in supporting the innovative efforts of companies, since the transfer of knowledge to
industries requires the entrepreneurial and scientific skills of universities, as these complement the innovative activities of companies (Oliveira, 2023).

Along with the growing difficulty in obtaining essential knowledge for the technological development process, industries were encouraged to increasingly resort to external sources of information, as a way of accelerating the progress of the conception and dissemination of technological innovations. According to Garcia et al (2014), this is because innovation rarely occurs in isolation. In most cases, companies' innovative initiatives integrate a set of external actions and agents whose qualifications complete and reinforce companies' internal R&D structures or organizations. Thus, innovation generation procedures have the support of several contributors, such as suppliers, users, universities and research centers (Nelson, 1996; Mowery et al., 2015; Garcia et al., 2014).

Authors such as Porter and Schumpeter consider training and technological innovation as the main factors that determine success in the competitiveness of companies and, consequently, countries. The good functioning of an entire network of teaching and research institutions, public and private, and government agencies, which carry out or support the execution of scientific and technological activities, including training of human resources, research, development and dissemination of technologies, and which constitute the "Innovation System" (Moraes; STAL, 1994).

In this way, the university has an important place in the National Innovation System, as it develops essential activities to stimulate innovation, such as: teaching and human qualification, training qualified workers, and creating new knowledge through scientific research (Souza; Marcondes; Pereira, 2020; Liboreiro, 2005).

The training of individuals is one of the purposes of the university, and it decisively influences innovation through the training of professionals, scientists and engineers, who will help companies. Another purpose of universities, which helps the innovation process in companies, is the formation of new knowledge arising from scientific research carried out by university teachers and students, which contributes to the scientific and technological growth of the economy. Therefore, scientific research produced at universities portrays the technological capacity of a country, influencing the ability of industries to generate scientific and technological knowledge and contributing
to the progress of society (Garcia et al., 2014; Souza; Marcondes; Pereira, 2020; Ruffoni; Melo; Spricigo, 2017; Liboreiro, 2020).

Scientific and technological development must be linked to the real needs of the country and, therefore, it can no longer be accepted that companies, universities and research institutes act independently of each other, despite the existence of specific roles and functions to be preserved (Moraes; Stal, 1994, p. 98-112).

The relationship between universities and companies is a key aspect of the competitiveness of industries and countries, as technologies present in research centers play a crucial role as innovative components, presenting the potential to generate competitive advantages through products and services. In this scenario, Science and Technology Institutions (ICT) play the role of suppliers, while companies act as consumers of these technologies (Oliveira; Silva, 2022).

According to the Organization for Economic Cooperation and Development (OECD), countries that have strong public research and innovation capacity, show high productivity gains and have a high capacity to deal with socioeconomic challenges (IEDI, 2020). Furthermore, research carried out by the OECD demonstrated that the increase in resources invested in R&D led to an increase in the economic growth of countries, thus, such a relationship is fundamental (Moraes; STAL, 1994).

According to the OECD, the prevailing understanding is that interactions between universities and research institutes are interactive and bidirectional. The co-creation of knowledge by firms and universities is essential to ensuring that innovation ecosystems benefit from scientific research. It can be said that co-creation is the most accentuated of university-company interaction and is formed while knowledge is built together through shared facilities and mixed groups. Furthermore, the direct participation of the government and civil society is a characteristic of the various ambitious forms of knowledge co-creation (IEDI, 2020).

To increase knowledge creation, industries began to invest in new allies, through strategic agreements and exchanges of information with research centers and universities (Segatto, 1996; Mota, 1999; Prado; Porto, 2002). Those responsible for the organizations
abandoned their closed stances and started looking for external partners, with the aim of reducing costs and increasing R&D returns (BIGNETTI, 2001). Based on this idea, the relationship between universities and industries is consolidated as an efficient way of creating and sharing knowledge (Gonçalo; Zanluchi, 2011).

Relevant knowledge co-creation initiatives include joint research laboratories and joint research projects, the establishment of new intermediary institutions, and the development of new guidelines for intellectual property management. Numerous OECD countries are promoting the joint development of joint research laboratories and public-private partnerships for knowledge co-creation (IEDI, 2020).

In developing countries, industries have a low level of R&D activities, that is, most companies do not have internal knowledge generation as a development strategy. Thus, in such countries, R&D activities are mainly concentrated in universities, which have been gaining greater prominence in this area, as they contribute to the generation of knowledge and increased business innovation (Segatto, 1996; Plonski, 1999; Prado; Porto, 2002). Therefore, in these countries, the relationship with universities must be intensified and, for a result to be innovative, there must be harmonious relationships between organizations, so that they can generate and reproduce the learning and knowledge creation processes (Gonçalo; Zanluchi, 2011; Sutz, 2000; Nascimento, 2011).

Interactions between universities and industries appear to be a promising way to achieve social and economic transformations, as they have revealed a commitment to society, making the relationship between these centers directly proportional to society's needs, thus, the chances relations between universities and companies grow, as society's growth needs increase (Gazzetta; Kato-Cruz; Endo, 2020).

The relationship between industries, universities and government can occur through different forms and agreements, from individual guidance from a professor to the formation of complex structures, such as: research laboratories, technology parks, technology transfer offices and research centers (SBRAGIA, 2006). According to Faulkner and Senker (1994) and Ipiranga, Freitas and Paiva (2010), in most cases, the university-company relationship is based on personal and non-institutional contacts.
Therefore, some circumstances and forms of cooperation between industries, universities and government were listed:

i. Informal relationships in which the university is not included: individual guidance, informal workshops and meetings to share knowledge, academic “spin-offs” in which industries are formed to provide products and services arising from research carried out;

ii. Formal relationships in which the three parts of the group draw up agreements: scholarships, postgraduate incentives, student internships, personal exchanges and employee specialization;

iii. Scope of a mediating institution: agreement relationships via third parties under the method of industrial associations, research institutes, institutional consultancy and offices with the function of placing interns and trainees in companies;

iv. Formal agreements without a defined objective: industrial sponsorship of research and development in college departments and support for public and private research;

v. Formal agreements with a defined objective: contracted research, joint research projects or programs, and established services such as prototype development and testing (Sbragia, 2006; Ipiranga; Freitas; Paiva, 2010).

Understanding the expectations and motivations that lead companies and universities to establish a collaboration for joint research requires a more in-depth analysis of the process, as well as an assessment of the potential benefits. The partnership between university and company not only provides individual advantages to those involved, but also contributes to the country's progress, promoting a more competitive and productive sector, high-quality research, more significant and rapid technological innovations, and the strengthening of the national economy (Ribeiro; Souza, 2021).

Thus, Ribeiro and Souza (2021) show some motivations for universities and companies to interact with each other, as shown in Table 2:
In the issue of the relationship between university, company and government, explained as a triple helix, there are a high number of cultural aspects, advantages, barriers, government policies, contractual forms and arrangements that are based on different purposes and motivations of the parties involved, which need to be taken into consideration (Ipiranga; Freitas; Paiva, 2010; Berni et al., 2015).

According to Moraes and Stal (1994), there are numerous advantages observed in this interaction: the university has the possibility of acting in the country's development, raising resources for the development of research, for quality investigations in its laboratories, and managing the technological projects. In the case of companies, they have advantages such as: technological development with low investment, proximity to university laboratories, updated technological modernization, among others.

According to Gomes and Perin (2022), there are factors that act as barriers, observed in the university-company relationship, which can hinder or interrupt this relationship. These barriers to involvement include several difficulties that can lead to a reduction in quality and productivity in interaction. The constant search for knowledge by universities, highlighting learning rather than development, as well as the creation of products, are one of the main barriers observed. This fact generates results that will be

Table 2 - Reasons for research centers and companies to interact with each other.

<table>
<thead>
<tr>
<th>Reasons for research centers to collaborate with companies</th>
<th>Reasons for companies to collaborate with research centers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raise additional resources for academic research, allocating funding to assistants, equipment and laboratories</td>
<td>Promote the development of new products and processes, improve the quality of existing products and realign the research and development (R&amp;D) agenda</td>
</tr>
<tr>
<td>Implement the practical application of the studies carried out</td>
<td>Attend seminars and workshops to gain access to the latest research</td>
</tr>
<tr>
<td>Promote the visibility of the university</td>
<td>Solve specific technical or design problems</td>
</tr>
<tr>
<td>Acquire knowledge about practical issues relevant to teaching activities</td>
<td>Maintain ongoing and networked relationships with other academic institutions</td>
</tr>
<tr>
<td>Create internship and employment opportunities for students</td>
<td></td>
</tr>
</tbody>
</table>

Source: Adapted from Ribeiro e Souza (2023).
achieved in the long term, a situation in which companies, in most cases, do not have this availability of time.

According to Maehler, Cassanego Junior and Schuch (2009), factors such as bureaucracy, cultural inequalities, lack of interest from academic staff and administration are reported as obstacles to establishing agreements with education, research and extension institutions. Likewise, in studies by Santana and Porto (2009), regarding researchers, bureaucracy is listed as one of the primary factors related to the difficulty of developing technology transfer processes (Berni et al., 2015).

In terms of facilitators of the university-company relationship, Gomes and Perin (2022) highlight some factors: the university is characterized by having a vast store of scientific knowledge, which is important for innovation and a factor of interest for companies. In fact, the increase in communication channels between industries and research centers is a facilitator that has been increasing in recent times.

According to Lopes (2013), cited by Berni et al (2015), there was no evidence that the relationship between university and company has a negative impact on academic production. Nor is there a need to protect or prevent relationships with extensive agreements that could reduce freedom of exploration. Therefore, it is believed that it is essential to formalize the relationship between universities and industries, however, this should not have complex contracts that harm the process of innovation and creativity (Berni et al., 2015).

Nowadays, especially in developing countries, the level of university-business interaction is not satisfactory. The most significant contribution of graduate schools is simply the training of qualified workers. Relationships, in most cases, are limited to information exchange activities and not high-level research (Sutz, 2000; Nascimento, 2011). This scenario occurs due to the barriers presented, which are relevant factors that limit the practical application of the university-company relationship. However, it is considered that the application of public-private partnerships, with their due formalizations and legal precepts, brings advantages to industries and undergraduate schools (Berni et al., 2015).
Thus, despite the difficulties observed in the application of the university-company relationship, factors that encourage this relationship can be observed. The company's awareness of the importance and benefits of interacting with the university stands out. Regarding the university, the formation of exclusive groups for research, construction and conservation of infrastructure to support joint research, as well as the creation of an exclusive body for matters related to interactions with industries, are among the main mechanisms for this stimulus. In the case of the government, we can mention the creation of science and technology programs, financing for technological research, and legislation that benefits companies that carry out research together with universities (Costa; Cunha, 2001; Fracasso, 1993; Alvim, 1998; Cunha, 1998; Fonseca, 1998; Costa; Cunha, 2000).

4 RESULT OF FOCUS GROUP

From the interviews carried out, as described in the methodology, relevant information was obtained to practically analyze the university-company relationship, as described below:

1. **What prerequisites do you consider necessary in the relationship between universities and companies?**

   It is important to highlight that it is essential to establish relationships, even if they are mediated by organizations, between universities and companies. Furthermore, it highlights the need for universities to have a portfolio of research under development and for companies to present identified opportunities for improvement. It is recognized that there is often a dichotomy between academic professionals and corporate technicians, suggesting the need for integration between these two fields.

   "It is important to align the parties' expectations and establish common objectives and agreed responsibilities. When completing each project together, I consider it important to list the positive and negative aspects of the relationship for improvements and fluid continuity of the relationship." - Altair Emboava, manager of Hitt - Technological Innovation Hub of Taubaté – São Paulo.
2. **How could the government facilitate the relationship between universities and companies?**

The government can promote incentive events for networking and offer some types of tax incentives. Promote specific environments and projects in which connections between universities and companies can intensify.

"The government should establish public policies with the purpose of facilitating this relationship through APL's (Local Productive Arrangement), encompassing not only companies, as is currently the case, but, mainly, bringing universities to demonstrate their research projects." - Lúcio Veraldo, CEO and Co-Founder of Infinity Academy 3D – São José dos Campos – São Paulo.

3. **What benefits do you see in this relationship?**

Collaboration between universities, companies and government would bring significant mutual benefits. Universities could expand their applied research, providing benefits to researchers and students. They would also apply theoretical knowledge in practice, which would promote a deeper understanding of the application of the content. Companies would have the opportunity to raise their levels of technical improvement by using qualified labor and academic laboratories and increasing their competitiveness. In addition to allowing access to academic expertise and scientific production, contributing to greater organization. For the government, this collaboration could attract more businesses, creating a prosperous environment for the community and increasing qualified opportunities, which would potentially result in greater revenues.

"Greater presence of the company at the University sharing pain points so that the university sector can think of solutions, whether through undergraduate work or master's or doctorate research." - Francisco Novaes, Coordinator of public policy projects at Technological Park Association of São José dos Campos, São Paulo and CEO of Soltcon Training and Financial Consulting LTDA.

4. **What barriers do you see in this relationship?**

Many businesspeople are not interested, and business associations resist for fear of the university taking over the consulting space. Furthermore, the lack of a history of
fluid communication and collaboration between these entities hinders the progress of relationships. The issue of intellectual property also represents a point of conflict, which can obstruct the continuity of collaborative partnerships. Due to their older nature, institutions face slow bureaucratic processes, which make it difficult to approach companies, which demand more agile and immediate processes.

"Many businesspeople are not interested, and business associations resist for fear of the university taking space from consultancies." - Helder Gomes, Professor and researcher at the Fluminense Federal University – Rio de Janeiro.

5. Do you consider a relationship to be positive? In other words, does the number of benefits outweigh the barriers encountered?

This relationship is positive and important, but a lot of dialogue is needed between the parties to increase trust and the presence of regulation. Furthermore, in Brazil, we could advance our technological development more quickly in several areas of knowledge.

"Greater presence of the company at the University, sharing pain, so that the university sector can think of solutions, whether through undergraduate work, master's or doctoral research." - Francisco Novaes, Coordinator of public policy projects at Technological Park Association of São José dos Campos, São Paulo and CEO of Soltcon Training and Financial Consulting LTDA.

6. In your opinion, what is the main role of universities, companies and government in the triple helix model?

The role of universities is to carry out research and training qualified and up-to-date workforces for the market, which is increasingly demanding and agile, in addition to researching and presenting innovative solutions to society's problems. The government, on the other hand, can act as a facilitator, creating incentive policies and providing a promising context. And companies, in turn, can define the problems and challenges perceived in the market, which generate opportunities for new research and sharing of financial resources, absorbing university students.
"The main roles are the university: researching and presenting innovative solutions to society's problems; the company: being able to hire these solutions to ensure better efficiency in its area of activity; and the government: providing elements of support through public policies." - Lúcio Veraldo, CEO and Co-Founder of Infinity Academy 3D – São José dos Campos – São Paulo.

5 FINAL CONSIDERATIONS

This research allowed us to understand the concepts of triple, quadruple and quintuple helices as applied to the university-company relationship, including the importance of this relationship, the advantages, barriers and facilitating aspects.

Furthermore, it was possible to see how innovation, entrepreneurship and technological knowledge are important in the university-company relationship. Thus, there is a need to encourage factors that stimulate this relationship, with the aim of reducing the relationship barriers identified, as, in the current context of globalization and high-level technology development, this cooperation is of great importance for the country, positively influencing technological advances.

It is suggested to continue this research with the identification of university-company relationship models, including aspects of technology transfer between universities and early-stage companies (startups), mainly in business incubation environments.

The bibliographical research carried out and the interviews with the Focus Group allowed us to have a comprehensive view of the relationship between universities, companies and government in the context of innovation and development. Therefore, there are points to be considered: the prerequisites outlined highlight the importance of aligning expectations, establishing common objectives and continuous evaluation. Although these aspects are crucial, the practical implementation of these recommendations can be challenging due to cultural and bureaucratic divergence between institutions.

Suggestions for government facilitation of the relationship include the promotion of networking events and tax incentives. However, the success of these initiatives depends
on the government's ability to create an environment conducive to collaboration, which may require additional long-term policy efforts and strategic investments.

Mutual benefits are highlighted, including the development of applied research, the technical improvement of companies and the creation of an environment favorable to economic growth. However, the materialization of these benefits can be affected by practical challenges, such as intellectual property issues and institutional bureaucracy.

The barriers identified include the lack of interest of some businesspeople, resistance from business associations and difficulties in communication and collaboration between entities. Overcoming these obstacles requires a concerted effort to promote a culture of cooperation and resource sharing.

Although there is recognition of the benefits of the relationship, it is important to consider that the identified barriers can impact the effectiveness of this partnership. Continuous dialogue between the parties and the implementation of regulatory mechanisms can help overcome these challenges and strengthen the relationship.

Universities are seen as generators of knowledge and qualified labor, companies as drivers of innovation, and the government as a facilitator and promoter of policies that encourage collaboration. However, an appropriate balance of responsibilities and resources is necessary to ensure the success of the triple helix model.

It is critical to recognize and address the practical challenges and nuances involved in implementing these partnerships to ensure their long-term success.
REFERENCES


