O PAPEL DAS INSTITUIÇÕES NO SUPORTE A INDIVÍDUOS NO DESENVOLVIMENTO DE INOVAÇÕES: O CASO DE UM ECOSSISTEMA ACADÊMICO DE INOVAÇÃO

[1]Camila Alves Damásio, [2]Sergio Evangelista Silva, Alana Deusilan Sester Pereira

[1]Universidade Federal de Minas Gerais (UFMG), [2]Universidade Federal de Ouro Preto (UFOP)
<camila.damasio@aluno.ufop.edu.br>, <sergio.silva@ufop.edu.br>,
<alana@ufop.edu.br>
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Resumo. O desenvolvimento de inovações tecnológicas envolve fenômenos sociais complexos resultantes da interação dos indivíduos dentro dos ecossistemas de inovação. Consequentemente, é essencial uma análise aprofundada sobre como indivíduos interagem e realizam suas atividades nestes ambientes. Este artigo examina a contribuição dos indivíduos, situados em múltiplos níveis institucionais, para o desenvolvimento de novas tecnologias e de suas próprias carreiras em um ecossistema acadêmico de inovação. Através de uma combinação das abordagens qualitativa e quantitativa, este estudo analisou os papéis desempenhados pelos indivíduos no desenvolvimento de 93 patentes dentro de uma unidade acadêmica da área de medicina no Brasil. Este estudo propõe uma estrutura de três níveis institucionais para o desenvolvimento de novas tecnologias: o nível individual, o nível da equipe, e o nível organizacional e interorganizacional. Dentro destes níveis, são identificadas vinte e uma subcategorias. Especificamente, no nível individual, foram identificados seis tipos de papéis. No nível da equipe, foram identificados três padrões de compartilhamento de conhecimento, três padrões intertemporais de transferência de conhecimento e cinco tipos de configurações da equipe. No nível organizacional e interorganizacional foram observados quatro tipos de arranjos. A principal contribuição teórica deste artigo reside em demonstrar como a estrutura institucional atua como mecanismo de apoio às ações dos indivíduos na criação de novas tecnologias, e no avanço de suas carreiras profissionais. Em termos práticos, os vários construtos identificados podem ser utilizados para avaliar o desenvolvimento institucional dos ecossistemas de inovação acadêmica e guiar a formulação de políticas destinadas a promover o seu crescimento.

Palavras-chave: ecossistemas de inovação; ecossistemas acadêmicos; patentes; inovações na medicina; redes.

THE ROLE OF INSTITUTIONS IN SUPPORTING INDIVIDUALS IN THE DEVELOPMENT OF INNOVATIONS: THE CASE OF AN ACADEMIC INNOVATION ECOSYSTEM

Abstract. The development of technological innovations involves complex social phenomena resulting from the interaction of individuals within innovation ecosystems. Consequently, a thorough analysis of how these individuals interact and frame their activities within these settings is essential. This article examines the contribution of individuals, situated within multiple institutional levels, to the development of new technologies and their careers in an academic innovation ecosystem. Through a combination of qualitative and quantitative approaches, this study analyzed the roles played by individuals in the development of 93 patents within a medical academic unit in Brazil. The findings of this study propose a framework based on three institutional levels that enable the development of new technologies: the individual level, team level, organizational level, and inter-organizational level. Within these levels, twenty-one sub-categories are identified. Specifically, at the individual level, six types of individual roles were identified. At the team level, three patterns of knowledge sharing, three intertemporal patterns of knowledge transfer, and five types of team configurations were identified. At the organizational and inter-organizational levels, four types of arrangements were observed. The main theoretical contribution of this article lies in demonstrating how the institutional structure acts as a supporting mechanism for individuals' actions in creating new technologies and advancing their professional careers. In practical terms, the various constructs identified can be utilized to evaluate the institutional development of academic innovation ecosystems and inform the formulation of policies aimed at fostering their growth.

Keywords: innovation ecosystems; academic ecosystems; patents. innovations in medicine; network.

1 INTRODUCTION

Despite the progress made in the literature, the understanding of how individuals with different social and institutional roles come together to form teams and drive technological innovation remains limited. Furthermore, most research on networks primarily focuses on collaborative efforts aimed at generating new scientific knowledge (Costa; Cabral; Nogueira, 2023; Affonso; Santiago; Dias, 2022; Silva *et al.*, 2019). There is a scarcity of studies that specifically examine collaboration in the production of new technologies within academia, and those that do exist are relatively recent (Caviggioli *et al.*, 2020; Modic; Luzar; Yoshioka-Kobayashi, 2023).

In academia new technologies are conventionally created in the context of academic innovation ecosystems, which are groups of academic institutions, such as universities, research institutes, technological parks, and foment agencies wherein individuals interact for the creation, sharing and transfer of scientific knowledge and new technologies (Leih; Teece, 2016; Silva *et al.*, 2020; Quatraro; Scandura, 2019). These ecosystems enable individuals to interact permitting the development of their skills for the creation of new knowledge (Granstrand; Holgersson, 2020; Walrave *et al.*, 2018). As such, given their complexity, it is possible to consider the structuration of academic innovation ecosystems, from a bottom-up perspective, through the actions of individuals through different institutional roles (Bella; Gandullia; Preti, 2021), by their interaction through research and development teams (Acosta *et al.*, 2020; Affonso; Santiago; Dias, 2022), and through the organizational and inter-organizational level that supports these activities, such as academic departments, university, research institutes, foment agencies, technology transfer offices (Modic; Luzar; Yoshioka-Kobayashi, 2023; Vonortas; Zirulia, 2015).

Despite all the evolution of literature about academic innovation ecosystems some gaps persist opening some research opportunities. At the individual level, the studies that approach individual interaction consider this phenomenon in terms of networks and collaboration without a perspective of the internal social roles of actors in the creation of new knowledge and technologies (Affonso; Santiago; Dias, 2022; Bella; Gandullia; Preti, 2021). At the team level, the current studies consider team formation, and the stability and intensity of collaboration networks for the creation of new knowledge (Acosta *et al.*, 2020; Dahesh *et al.*, 2020), without considering the several configurations of teams. At the organizational and inter-organizational levels, the studies are focused on technology transfer (Battaglia; Landoni; Rizzitelli, 2017; Brescia; Colombo; Landoni, 2016; Caviggioli *et al.*, 2020), and other internal structural configurations such as the research laboratories of universities (Shibayama; Baba; Walsh, 2015), without consider the types of organizational structures that support the development of new technologies. In the context of innovation ecosystems, it is important to mention the study of Good *et al.* (2019) that considers three levels for the creation of new technologies, the individuals, the rules that guide their actions, and their actions guided by these rules.

Additionally, in the Brazilian context are still scarce and recent studies about academic innovation ecosystems (Chaves, 2016; Costa; Cabral; Nogueira, 2023; Silva; Furtado; Vonortas, 2018), whereas new studies and perspectives are welcome, the configuration of some aspects of academic innovation ecosystems in a development country. As such, there is still an encompassing perspective capable of explaining better how individuals playing different social roles, and engaged in teams create new technologies thanks to the support of academic innovation ecosystems.

This article analyzes how individuals framed in multiple institutional layers contribute to the development of new technologies and their careers in an academic innovation ecosystem. The study aims to identify the various social roles undertaken by individuals within teams and their relationships with organizations in the context of a Brazilian academic innovation ecosystem focused on medicine. It is guided by the following research questions: i) – what are the social roles of individuals in an academic innovation ecosystem? ii) – how are they engaged in teams interacting for the creation of new technologies and their professional formation? iii) – what organizational and inter-organizational structures give support for these processes? The analysis focuses on individuals and organizations involved in the development of 93 patents by an academic unit between 1988 and 2020. The research adopts a combination of qualitative and quantitative methods, using an inductive approach to uncover the evolutionary pattern of the academic unit and its individuals in the realm of technological innovation.

2 LITERATURE REVIEW

2.1 Collaboration networks and innovation ecosystems

The study of technological innovations in the literature can be approached from two perspectives. The first focuses on the entities and processes involved in the creation of new technologies (Rayna; Striukova; Darlington, 2015)(. The second examines the impacts of technological innovations on the economy and society (Kovács; Carnabuci; Wezel, 2021). This article aligns with the first perspective, assuming that most technological innovations are intentionally generated by individuals (Parjanen, 2012). Like scientific advancements, the creation of technological innovations in modern times is often the result of collective processes, within a sociotechnical context (Phelps; Heidl; Wadhwa, 2012).

Scientific and technological collaboration plays a crucial role in the generation of new knowledge, including the development of new theories and technologies (Schweitzer; Breudel, 2021). Collaboration has become increasingly necessary in today's specialized workforce, where jobs are marked by intensive knowledge (Kraft; Bausch, 2018). These collaborative networks facilitate the exchange of diverse knowledge (Silva *et al.*, 2019), allowing for the creation of complex knowledge (Jiafu; Yu; Tao, 2018; Rodan; Galunic, 2004).

Collaboration networks can be classified into two main categories: academic and non-academic networks (Brescia; Colombo; Landoni, 2016). Non-academic networks typically focus on developing products with commercial viability (Costa; Cabral; Nogueira, 2023; Ponds; Oort; Frenken, 2007). In contrast, academic networks can be oriented towards the development of new scientific knowledge (Affonso; Santiago; Dias, 2022) or new technologies (Modic; Luzar; Yoshioka-Kobayashi, 2023). The latter type of arrangement often involves cooperative projects between universities, firms, and other societal organizations (Chaves, 2016; Silva; Furtado; Vonortas, 2018).

The study of collaboration networks has been employed to examine knowledge flows within and between organizations(Zhang; Liu; Wei, 2019). While individuals and their participation in teams are essential for the creation of new technologies, it is important to recognize that this occurs within institutional settings (Brescia; Colombo; Landoni, 2016; Munari *et al.*, 2016). Collaboration for innovation often involves interactions between different types of organizations, each with unique competencies and resources, such as universities, research institutes, and firms, within a complex institutional context (Bella *et al*, 2015). These contexts are referred to as innovation ecosystems and will be discussed in the next subsection

2.2 Innovation ecosystems

The innovation ecosystem is an institutional structure that facilitates the development of new technologies (Dahesh *et al.*, 2020; Ritala *et al.*, 2013). It consists of individuals with diverse social roles such as entrepreneurs, investors, project managers, engineers, and others. These individuals operate within specific spatial settings and benefit from institutional structures that support and promote innovative activities (Liu *et al.*, 2020; Walrave *et al.*, 2018). Good *et al.* (2019) describe innovation ecosystems as composed of three main elements: people, who possess the necessary capabilities and operate within the ecosystem; structure, which defines the rules, social roles for individuals; and activities, which encompass the various actions performed within these systems.

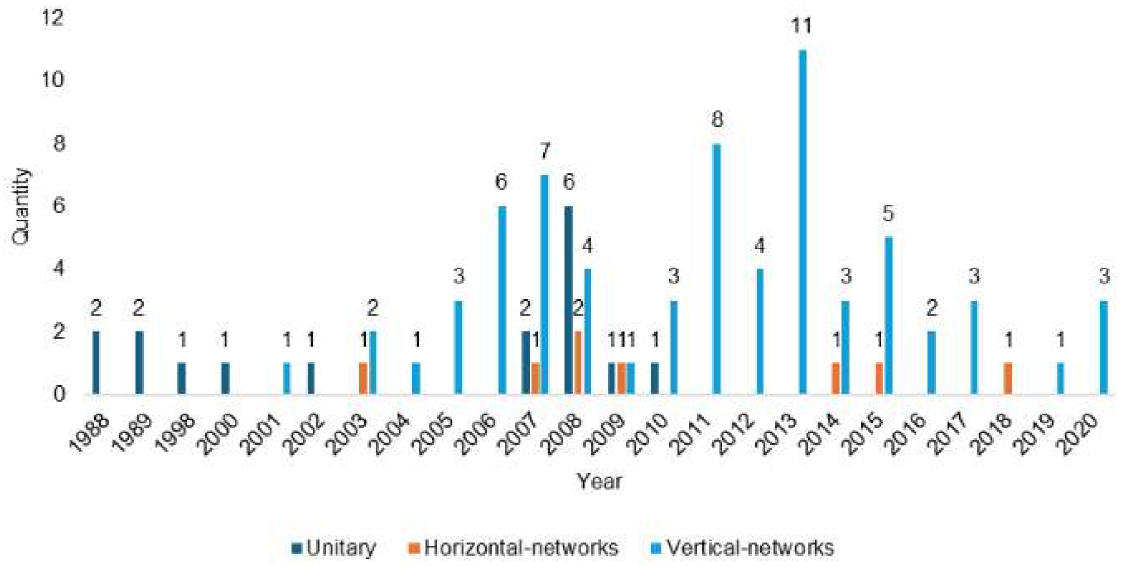
Additionally, each innovation ecosystem has unique geographic and socioeconomic characteristics, as well as a specific industry and knowledge domain with which it is associated (Granstrand; Holgersson, 2020; Radziwon; Bogers; Bilberg, 2017). Within an innovation ecosystem, the collaboration between public and private entities plays a crucial role in fostering technological advancements (Liu *et al.*, 2020). In this context, the triple helix concept states the importance of the interaction between three types of actors, the public, private and academic, wherein each one with its respective competencies and interests, may cooperate to develop and diffuse innovations (Etzkowitz; Leydesdorff, 2000). In this interaction, the private agents are capable of generating new business opportunities, while academic agents are capable of creating new knowledge and technologies, and the government are capable of supporting the process in complementary ways, such as fomenting of development of new technologies (Yoda; Kuwashima, 2020). Based on the literature, there are two main types of innovation ecosystems: industrial ecosystems and academic innovation ecosystems. Industrial ecosystems involve private agents dedicated to the development of contemporary technologies (Granstrand; Holgersson, 2020; Liu *et al.*, 2020), while academic innovation ecosystems are characterized by the central role of universities as creators of innovations (Leih; Teece, 2016).

In academic innovation ecosystems, individuals assume various social roles such as teachers, students, managers, entrepreneurs, inventors, and other administrative positions to carry out their labour activities (Fischer; Moraes, 2015). Moreover, the establishment of university-industry links is crucial for the development and transfer of new technologies to society (Costa; Cabral; Nogueira, 2023; Kang; Motohashi, 2020). These systems encompass several supporting entities such as business incubators, science parks, investors, government funding agencies, technology transfer offices, and startups (Battaglia; Landoni; Rizzitelli, 2017).

3 METHODOLOGY

The steps of the methodology implemented in this study are presented in Figure 1. Firstly, was identified a relevant academic innovation ecosystem for the development of theory. As such, this study focuses on an academic innovation ecosystem in Brazil that is dedicated to medical education, research, and technological development. The ecosystem emerged with the establishment of the medicine faculty, referred to as the medicine academic unit (MAU), in the 1940s. The choice of MAU is due to its long history and development in the medical field, and its important positive impact on the social, humanitarian and economic aspects of Brazilian society.

Figura 1: The steps of methodology.



The MAU has played a central role in shaping the innovation ecosystem by providing healthcare services and academic programs ranging from undergraduate to postdoctoral levels. The MAU is an integral part of a large public university in Brazil and is situated alongside other academic units focused on health-related disciplines such as pharmacy, nursing, and dentistry.

The second step consisted of the identification of the patents deposited by the MAU in the Instituto Nacional de Propriedade Indústrial (INPI), which is the Brazilian institution that controls de intellectual property assets in Brazil. There were identified a total of 93 patents deposited by the MAU and its partner organizations from the year 1988 until 2020. Patents are an important indicator of technological innovation, widely considered in the innovation literature (Caviggioli *et al.*, 2020; Kang; Motohashi, 2020). After the identification of the 93 patents, the third step involved the identification, through the documental search in the Lattes database, a Brazilian database with the complete curricula of researchers, the data of 219 researchers who participated in the patents. There were recovered the curriculum of 210 researchers that were screened according to the purpose of this research. This strategy for documental analysis of multiple sources is in line with other studies in the literature (Lee *et al.*, 2020; Zhang; Liu; Wei, 2019).

Based on a bottom-up perspective the fourth step focused on the screening of the professional evolution of the individuals who participated in the creation of the patented technologies. In general, among the 210 inventors, it was found that several of them collaborated in the development of more than one patent, resulting in a total of 315 participations. On average, each inventor contributed to the development of 1.43 patents. By analyzing the inventors' curricula, it was possible to track their professional evolution over time. The fifth step was based on the team perspective which screened the team formation in each patent, their intertemporal evolution, through the repetition of teams partially or integrally. The sixth step was focused on the identification of organizational arrangements, that is, inside the MAUs' university, and inter-organizational arrangements, which are those between the MAU and external agents, such as universities, research institutes and firms.

3.1 Data treatment and generation of theory in a multiple-level perspective

This research involved multiple levels of categorization and abstraction, which is a common practice in qualitative inquiry (Corbin; Strauss, 1990). The researchers engaged in a systematic process of analyzing the data to uncover meaningful patterns and categories, examine the data from various perspectives, abstracting and categorizing the information at different levels of abstraction (Welch; Rumyantseva; Hewerdine, 2016). Through this iterative process, categories are identified, refined, and organized, leading to the development of a theoretical framework that captures the relationships and patterns observed in the data.

ical framework that captures the relationships and patterns observed in the data. The data treatment involved a multilevel approach, which encompassed three levels of analysis: Social roles: this level focused on the examination of the various social roles played by individuals in the development of technological innovations. These roles included senior researcher, junior researcher, PhD student, master student, and undergraduate student. Team composition and evolution: At this level, the composition of teams formed for the development of technological innovations was analyzed. The study explored how these teams were assembled, their structure, and how they evolved over time. Factors such as team dynamics, collaboration patterns, and the addition or departure of team members were considered. Organizational level: This level delved into the patterns of interaction among individuals, teams, and organizations involved in the development of technological innovations.

By analyzing the data at multiple levels, the study aimed to obtain a comprehensive understanding of the social dynamics, team composition, and patterns of interaction within the academic innovation ecosystem. This approach allowed for insights into the contributions of individuals, teams, and organizations to the development of technological innovations.

4 RESULTS

4.1 The roles of individuals in the development of new technologies

The screening of the inventors' curricula revealed that individuals with different levels of professional experience participated in the production of new technologies (Table 1). By considering the highest degree obtained by the participants at the moment of the patent deposit, the majority of them already were senior researchers.

Quadro 1: Social roles of internal and external patent participants in the MAU.

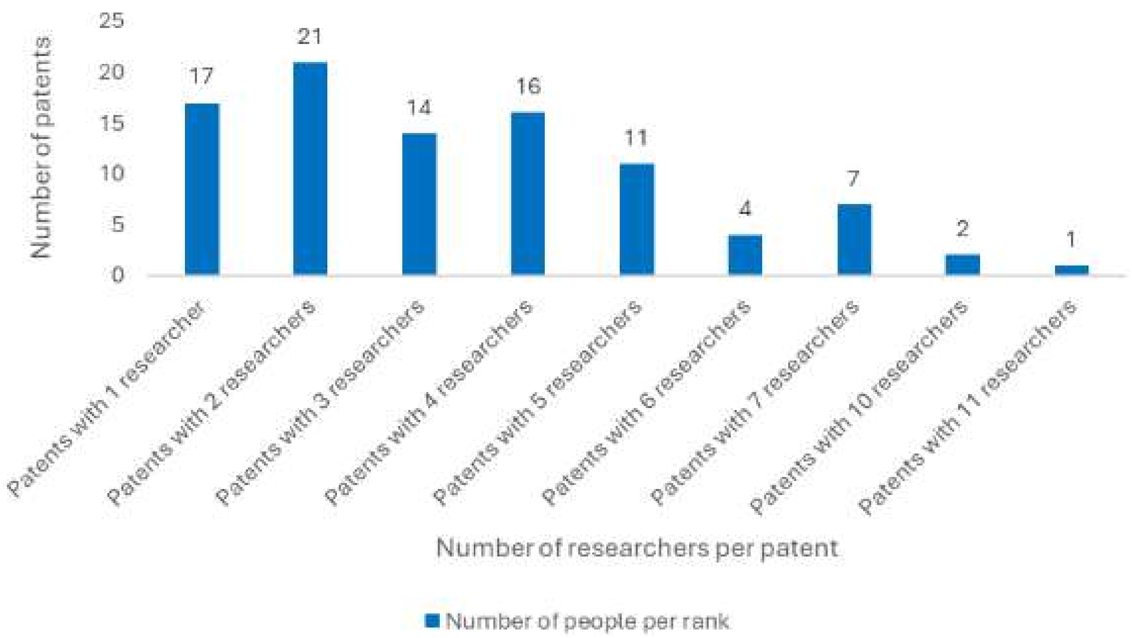
	Social role	**Quantity**
Inventors that pertain to the MAU and external to MAU	Senior researcher	98
	Junior researcher	51
	Ph.D. students	33
	Master students	13
	Undergraduate students	15
	Total	**210**

To comprehend the impact of MAU on the advancement of inventors in their academic careers the study analyzed their progression in academic degrees, including undergraduate students, master's students, Ph.D. students, junior researchers (those who obtained their Ph.D. in less than 5 years), and senior researchers (those who obtained their Ph.D. in more than 5 years). Additionally, the study examined their participation in research and innovation teams. These data were further categorized based on the institutional backgrounds of the inventors. The results suggest that in the context studied, is required a more mature professional knowledge and ability for the members of teams for the development of innovations. Screening the academic evolution of the 210 that participated in the patent creation, only Out of the total of 210 inventors identified, only 14 (6.6%) demonstrated progress in their academic careers by attaining a higher academic degree through their involvement in different patent development. Notably, these numbers varied among different groups: 8 inventors were internal to the MAU, 5 belonged to other departments within the same university, and only 1 inventor hailed from an external organization. This finding suggests that the impact of technology development in the MAU on the academic advancement of inventors is relatively limited. Despite the observed low rates, it is worth noting that the academic unit holds an advantage in this aspect compared to other departments and external organizations, based solely on the patents studied.

4.2 Formation of teams for the development of new technologies

An important piece of information that reveals the role of MAU as an environment capable of facilitating the formation of partnerships between individuals for the development of patents is that most patents (76) involve the participation of more than one inventor. However, 17 patents were created by a single inventor. Additionally, most of the teams were composed of 2 to 4 members (Figure 2). This find suggests that in the MAU context, small teams are more likely to occur, what happens probability by the facility of formation of small teams, due to communication, governance and construction of trust between the leaders of the projects.

Figura 2: The histogram of the number of patents and the quantity of individuals.



Five types of teams were identified based on the origins of the members who participated in the development of new technologies (Table 2): teams with members who work exclusively in MAU, teams with members who work in both MAU and other academic departments within the same university, teams with members from MAU and external organizations outside the university, teams with members from MAU, other academic departments, and external organizations, and teams where all members are from other academic units within the same university.

Considering the distribution of these teams over time, it was observed that from 1988 until 2002, during the initial stage of MAU's development, all teams were formed by internal members of MAU. However, after 2002, teams with members from different origins began to form, indicating a new stage of maturity for MAU.

Of the five types of teams, the most common formation was that of inventors working at MAU and other departments within the same university. The external inventors were typically from other academic units, such as chemistry, pharmacy, and engineering, who were also educators and researchers. On the other hand, members from external organizations outside of MAU's university also participated in the development of new technologies,

Quadro 2: The organizational and inter-organizational arrangements for patent creation in MAUs' context.

Ano	Arrangement with people only from MAU	Arrangement with MAU people and people from other academic units	Arrangement with MAU people and people outside of MAU units	Arrangement with MAU, MAU and external units	Arrangement with external persons, without the participation of MAU members
1988	2				
1989	2				
1998	1				
2000	1				
2001				1	
2002	1				
2003	1			2	
2004		1			
2005	1			2	
2006	3			3	1
2007	1	5	1		1
2008	9	1	2		
2009	1	2			
2010	2	1			
2011	2	5		1	
2012	1	1			
2013	3	6		2	
2014	3				
2015	2		2	1	
2016	1				1
2017		3			
2018	1				
2019					
2020		2			1

collaborating with companies or public foundations operating in the health sector.

Ninety-three arrangements for the development of patented technologies in MAU were identified and classified into three types (Figure 3). Seventeen (18.27%) arrangements were formed by single inventors who worked solely on the development of the technologies. This type of arrangement was mainly observed in the early stages of MAU's development, with the last patent created under this arrangement being in 2010. In this case, it can be inferred that the development of the patent did not foster knowledge or experience sharing between these inventors and other individuals in MAU.

The second group identified consisted of inventors with the same academic level, primarily senior researchers, involved in the development of new technology. These teams were referred to as horizontal teams and accounted for 8 (8.6%) arrangements. While these teams certainly involved knowledge sharing among the participants, it is expected that this type of arrangement would contribute minimally to individual career development within the academic unit.

However, in the remaining 68 (73.11%) arrangements, vertical teams were formed, consisting of individuals with varying levels of experience in their academic careers (e.g. senior researchers, junior researchers, PhD students, etc.). Therefore, it is reasonable to assume that the existence of teams with inventors possessing asymmetrical levels of experience would enable less experienced inventors to learn from their more experienced counterparts.

Finally, in the 76 arrangements that involved more than one inventor, it was examined how many arrangements exhibited partial repetition, where some inventors who had previously collaborated on an invention worked together again for the development of a new technology. Additionally, the study investigated how many arrangements showed total or partial repetition in terms of their formation (refer to Figure 4). A total of 32 teams, representing 42.1% of the total, repeated the composition of individuals in the development of new technologies. Out of these, 16 teams (21.05%) completely replicated a previous formation, while the remaining half exhibited partial repetition in their formation.

Figura 3: Quantity of arrangements for the development of new technologies and their configuration.

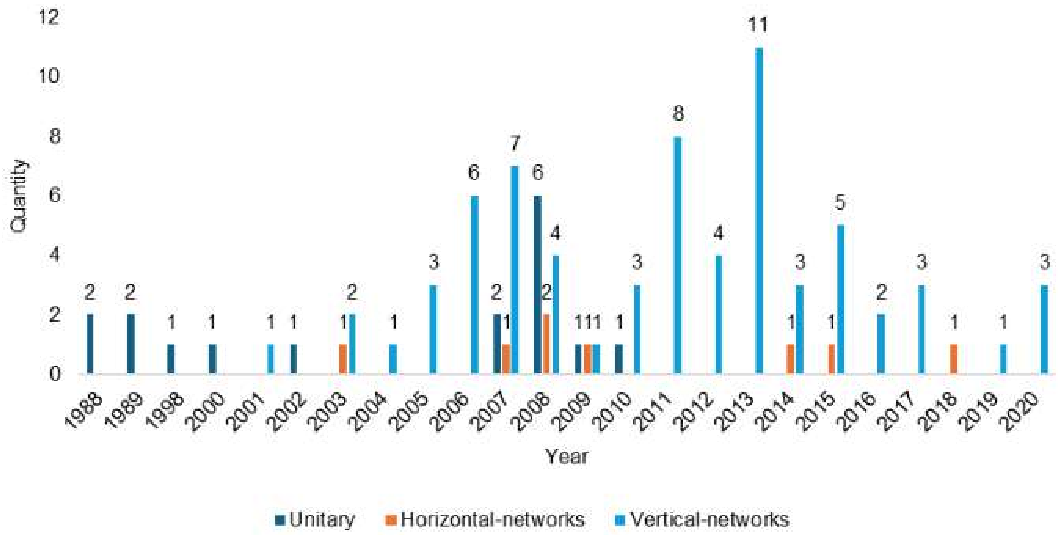
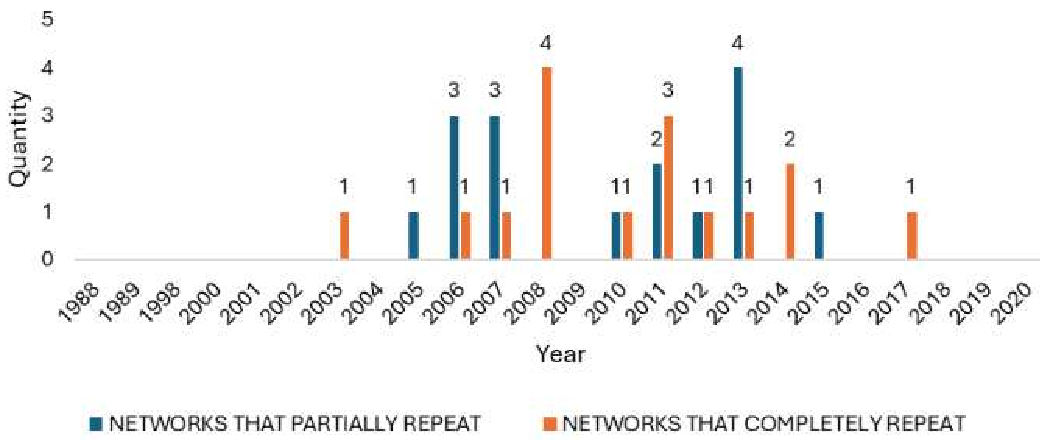


Figura 4: Quantity of repetition of teams in the development of new technologies.



4.3 The academic innovation ecosystem supports the development of new technologies

While MAU served as the primary focus of this study, a significant participation of inventors external to this academic unit was observed (Table 3). Three main types of inventors were identified based on their institutional affiliation at the time of patent deposition: inventors affiliated with MAU, totalling 89 inventors (42.38%); inventors working in other academic departments within the same university as MAU (referred to as other departments), totalling 82 inventors (39.04%); and external inventors working in organizations outside the university where MAU is located, totalling 39 inventors (18.57%).

Table 3 shows that most inventors who participated in patents deposited by MAU are external to this academic unit, which indicates its significant openness enabling the involvement of individuals from its external environment in the development of new technologies. It is also noteworthy to emphasize that the cycle of interaction between inventors working at MAU and external inventors commenced only in 2001, twelve years after the first invention.

Quadro 3: Individual evolution of inventors during participation in the development of new technologies.

Roles developed	Number of inventors
MAU Internal Inventors	89
Academic unit that pertains to the same Maus' University	82
External Agent to the Maus' University	39
Inventors did not find the origin	9
Total	**219**

This suggests an initial phase characterized by a relatively immature creation of new technologies, followed by a subsequent cycle of interaction between inventors within the academic unit and external inventors.

Finally, from an inter-organizational perspective, nine types of organizational arrangements for the development of new technologies were identified (Table 4). It is important to highlight that several patents received support from funding agencies, and MAU collaborated with other universities, companies, and public foundations in the development of new technologies.

Quadro 4: The scenario of collaboration between MAU and other organizations in the development of patents

Patent Owners	Quantity	Percentual
Only MAU	30	32,26%
MAU and other departments of the same university	28	30,11%
MAU with the support of foment agencies	8	8,60%
MAU and other universities	7	7,53%
MAU and public foundations	6	6,45%
MAU and firms	5	5,38%
MAU, other departments and firms	4	4,30%
MAU, other departments with the support of foment agencies	3	3,22%
MAU, other departments and public foundations	2	2,15%
Total	**93**	**100%**

5 DISCUSSION

This article proposes that the academic innovation ecosystems are comprehended by three institutional levels that are enacted to enable the development of new technologies, individual level, team level and organizational and interorganizational level. The study was implemented departing from the analysis of MAU, an academic ecosystem in the medical field, that pertains to a big Brazilian university. Considering the analysis of the structuration of the academic innovation ecosystem in the MAU context, from the three-level perspective this article presents in the following paragraphs its contributions to the literature.

This study is in line with (Leih; Teece, 2016; Modic; Luzar; Yoshioka-Kobayashi, 2023) identified the development of new technologies, in the context of an academic innovation ecosystem. Besides nowadays great part of the scientific effort is dedicated to the generation of new scientific knowledge, furthermore, published in the form of articles, this study dedicates the attention that these settings also can use the scientific knowledge for the creation of new technologies.

This research uses the conceptual lenses that consider the formation of academic innovation ecosystems from three levels, individual, team, and organizational and interorganizational. Through the application of this conceptual framework for study MAUs this study corroborates the individual level studies such as Bella, Gandullia e Preti (2021), in the team level Acosta *et al*. (2020) and Affonso, Santiago e Dias (2022), and in the organizational and inter-organizational level Modic, Luzar e Yoshioka-Kobayashi (2023) and Vonortas e Zirulia (2015). However, besides the confirmation of several authors, this study integrates the multiple perspectives in a systematic view, permitting a better understanding of how the articulation of the three levels of academic innovation ecosystems, whereas individuals play social roles in teams, supported by their organizational and the inter-organizational arrangements is responsible for the creation and diffusion of new technologies based on scientific knowledge.

As such the specific contributions of this study for each of the three levels are the following. At the individual level, it corroborates the current studies confirming that the formation of collaboration networks is fundamental for the creation of new technologies (Affonso; Santiago; Dias, 2022; Bella; Gandullia; Preti, 2021). However, this study finds different institutional roles played by individuals in these networks, ranging from undergraduate students to senior researchers, which suggests that in addition to permitting the creation, these networks also permit the vertical knowledge sharing and the professional formation of less experienced researchers through the contact with more experienced ones.

At the team level, this study confirms the importance of the stability of collaboration networks stated by (Acosta *et al.*, 2020; Dahesh *et al.*, 2020) through the identification of partial or total repletion of inventors in different patents. In addition, it found different configurations of collaboration networks considering the number of agents and their professional experience, since teams with inventors with the equivalent level of formation, such as a team composed only of senior researchers, until levels with individuals with different levels of professional experience, such as those comprehended by undergraduate, master and PhD students and juniors and senior researchers. Considering the number of inventors, this article is founded on single inventors' arrangements, until teams with seventeen inventors, whereas the majority of teams have between two and four inventors.

At the organizational and inter-organizational level, this study corroborates (Chaves, 2016; Silva; Furtado; Vonortas, 2018) that considers the cooperation of different types of organizations for the development of new technologies. However, it founded different types of inter-organizational frameworks used for the development of new technologies, identifying intra-organizational arrangements, between researchers of different departments of the same university, and interorganizational arrangements such as between researchers of different universities, research institutes and firms. Additionally, there was verified an expressive quantity of inventors external to the MAUs' context in the patents. These findings expand the current view of academic innovation ecosystems focused mainly on the academic structure dedicated mainly to technology transfer (Battaglia; Landoni; Rizzitelli, 2017; Brescia; Colombo; Landoni, 2016; Caviggioli *et al.*, 2020; Shibayama; Baba; Walsh, 2015). As a result, it presents an integrative perspective on how new technologies are created in an academic innovation ecosystem. Lastly, considering the ownership of the patents deposited by MAU it was verified diverse situations, with patents owned only by MAU, until patents where this unity has shared ownership with firms, public foundations, and external universities, among others, indicating, in this case, the intense support of the organizational and inter-organizational structures for patent creation.

Considering the three research questions that guided this study, it presents a detailed view of the social roles played by individuals in an academic innovation ecosystem, how they are engaged in teams for the creation of new technologies, and how organizational and inter-organizational structures support this process. In sum, it shows how different social roles and organizational and inter-organizational structures are combined to support the development of new technologies in an academic innovation ecosystem, permitting a better understanding of this important phenomenon for social and economic development.

6 CONCLUSION

This article examines how individuals are situated within multiple institutional layers in an academic innovation ecosystem to foster the development of new technologies and advance their careers. It specifically focuses on identifying the diverse social roles played by individuals within teams and their relationships with organizations in this environment. Considering previous studies on the development of academic innovation ecosystems, this study recognizes the individual as a central figure in the process of technological innovation, through the playing of different social roles through associations with teams and organizations, facilitating the development of technological innovations.

Even though individuals play a crucial role in the creation of new technologies within an innovation ecosystem, their innovation potential is facilitated and shaped by institutions operating at different levels of abstraction. This perspective not only reinforces the importance of institutions in innovation ecosystems, as highlighted in previous studies (Good *et al.*, 2019; Granstrand; Holgersson, 2020; Walrave *et al.*, 2018).

The article presents the following contributions to the theory of innovation ecosystems. First, it presents an integrated framework that elucidates the role of institutional structures in supporting the development of new technologies at four levels of abstraction. Second, it contributes to the empirical understanding of innovation ecosystems by analyzing patents created in an academic unit of an academic innovation ecosystem. It provides detailed insights into the social roles assumed by individuals involved in the development of new technologies, the teams' configurations that facilitate knowledge exchange between experienced and less experienced inventors, and the support provided by various types of organizations in the ecosystem for the development of new technologies.

As a contribution to the practice, the framework proposed can be used as a tool for planning and assessing the development of academic innovation ecosystem at different scope levels. This framework can guide policymakers and other stakeholders in designing and evaluating innovation policies and initiatives within these ecosystems. For example, this can take place through the creation of context to develop technologies with the formation of multidisciplinary teams and with members with diversified levels of professional experience, which can stimulate vertical knowledge sharing and the consolidation of an academic innovation ecosystem. The main limitation of this article is that it is based furthermore in documental data, and several of their findings can be further explored in studies capable of applying complementary methods such as interviews and surveys.

As suggestions for future studies, other potential research avenues include exploring the role of intellectual property rights and the impact of patenting on the development of technological innovations in academic innovation ecosystems, and the role of the existing arrangements on the diffusion of the new technologies.

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