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Open innovation in the development of medical technologies

O papel da inovação aberta no desenvolvimento de tecnologias na Medicina

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Abstract

Introduction: This article analyses how an academic unit in the medical field in a public Brazilian university implemented open innovation partnerships with external agents. It involved the identification of the types of arrangements, external agents, and knowledge accessed externally. **Method:** These initiatives were analyzed through the identification of two basic constructs, types of arrangements enacted, and types of knowledge accessed. **Results:** Two types of arrangements were identified, horizontal and vertical, three types of external partners, external academic departments, firms, and public services foundations, and two basic types of knowledge, knowledge creation in project teams, and knowledge about diffusion (dissemination) channels. **Conclusions:** This study should be improved through its replications in other universities and research institutes to identify the use of open innovation for development and diffusion of technologies. This article presents insights for universities to assess and plan open innovation arrangements. The insights revealed in this article can be used as an instrument for strategic planning of open innovation actions of academic units in universities for the development and diffusion of technologies useful for society. This article contributes by showing in detail how an academic unit of universities enacts arrangements to access external knowledge, and what types of knowledge are accessed externally to complement its internal competencies.

Keywords: Open innovation; University-industry; Knowledge channels; Market channels; Societal innovation; Social channels.

Resumo

Introdução: *Este artigo analisa como uma unidade acadêmica da área médica de uma universidade pública brasileira implementou parcerias de inovação aberta com agentes externos. A análise envolveu a identificação dos tipos de arranjos, agentes externos e conhecimento acessado externamente.* ***Método:*** *Essas iniciativas foram analisadas por meio da identificação de dois construtos básicos: tipos de arranjos implementados e tipos de conhecimento acessado.* ***Resultados:*** *Foram identificados dois tipos de arranjos, horizontal e vertical, três tipos de parceiros externos, departamentos acadêmicos externos, empresas e fundações de serviços públicos, e dois tipos básicos de conhecimento: criação de conhecimento em equipes de projeto e conhecimento sobre canais de difusão (disseminação).* ***Conclusões:*** *Este estudo deve ser aprimorado por meio de replicações em outras universidades e institutos de pesquisa para identificar o uso da inovação aberta para o desenvolvimento e a difusão de tecnologias. Este artigo apresenta insights para que as universidades avaliem e planejem arranjos de inovação aberta. Os insights revelados neste artigo podem ser utilizados como instrumento para o planejamento estratégico de ações de inovação aberta de unidades acadêmicas em universidades para o desenvolvimento e a difusão de tecnologias úteis para a sociedade. Este artigo contribui para a literatura ao mostrar em detalhes como uma unidade acadêmica de universidades implementa arranjos para acessar conhecimento externo e quais tipos de conhecimento são acessados externamente para complementar suas competências internas.*

Palavras-chave: *Inovação aberta; Universidade-empresa; Canais de conhecimento; Canais de mercado; Inovação social; Canais sociais.*

INTRODUCTION

The concept of open innovation has gained considerable emphasis in the last few decades due to its importance for organizations to access external knowledge that is fundamental for its innovative activities (Chesbrough & Brunswicker, 2014; Ottonicar & Valentim, 2021; Pihlajamaa, 2023). It is performed by firms in the continuous search for competitiveness (Bäck & Kohtamäki, 2015), and by other organizations seeking better alignment with social demands (Rauter, Globocnik, Perl-Vorbach, & Baumgartner, 2019), involving knowledge interchange between an organization and its environment.

Until recently the open innovation literature has mostly focused on studying this phenomenon from the perspective of firms (e.g., Shaikh & Randhawa, 2022), focusing on how they gain competitiveness using open innovation to develop new products and access markets (Urbinati, Chiaroni, Chiesa, & Frattini, 2020). Accordingly, there are studies about open innovation in big companies (Chesbrough & Brunswicker, 2014), in small and middle enterprises (Singh, Gupta, Busso, & Kamboj, 2021; Milici, Ferreira, Pereira, Carayannis, & Ferreira, 2023), and in startups (Villasalero, 2014; Díez-Vial & Montoro-Sánches, 2016).

Considering the new possibilities for the evolution of open innovation literature, it is important to focus on contemporary issues such as sustainability (Yang, Vladimirova, & Evans, 2017), non-profit organizations (West &

Bogers, 2017), and a holistic social perspective (Eppinger, 2021). To achieve this, it is necessary to consider how actors beyond firms implement open innovation. In this context, universities can also be considered protagonists of open innovation initiatives. However, in most cases, studies involving open innovation in universities are focused on the benefits generated for firms (e.g., Dong & Netten, 2017; Fernandes, Cesario, & Barata., 2017). There are still few studies investigating the gains of open innovation focused on the university perspective. For example, Alexander, Miller, and Fielding (2015) state the important role that universities can play in open innovation initiatives to generate benefits for society. In this same vein, Beck et al. (2022) study the role of open innovation in the context of academic collaboration for the development of new technologies. In this perspective, Huggins, Prokop, and Thompson (2020) investigate the effects of university centrality on its capacity to disseminate new technologies for society.

Despite the progress made in open innovation literature, studies that challenge the pure market perspective and explore how open innovation can be used to generate social benefits are needed (e.g., Ribeiro & Shapira, 2020; Inomata, Passos, Pintro, Sena, & Bedin, 2020; Eppinger, 2021). It is also necessary to better understand what types of external knowledge organizations access through open innovation agreements (Cassiman & Valentini, 2016; Angelidou, Mount, & Pandza, 2022).

This article analyses how an academic unit dedicated to the medical field in a public Brazilian university implemented open innovation partnerships with external agents. It involved the identification of the types of arrangements, of external agents with which the partnerships were established, and of knowledge accessed externally. The research was guided by the following research questions: how did an academic unit of a university implement open innovation with external partners? What were these external partners, the institutional arrangements enacted, and the types of knowledge interchanged? Through a qualitative approach there were researched 15 patents created by this academic unit in partnership with external agents. These initiatives are accessed through the identification of two constructs, types of arrangements enacted, and types of knowledge accessed. It permitted the identification of two types of arrangements for implementing open innovation, horizontal, through cooperation with academic departments of different universities, and vertical, through cooperation between the academic unit with firms or public foundations capable of diffusing new technologies. It identified two types of knowledge accessed externally, with two variations each, namely, scientific knowledge (interdisciplinary or multidisciplinary), and knowledge about dissemination channels, through social service channels or market channels.

In addition to this introductory section, this article is organized as follows: Section 2 presents the literature review of the main concepts related to this study. Section 3 describes the method used to perform the research. Section 4 presents the empirical results and is followed by the discussion (Section 5). Section 6 presents the conclusions of this study and its implications for the theory and practice of the open innovation field.

LITERATURE REVIEW

Open innovation can be pursued through research and development efforts (Janeiro, Proença, & Goncalves, 2013; Bäck & Kohtamäki, 2015; Vieira, Bonfim, & Cruz, 2021), by accessing technical or marketing knowledge external to an organization (Urbinati et al., 2020; Ottonicar & Valentim, 2021). The stages of open innovation collaboration involve idea generation, product/process development, and commercialization (Urbinati et al., 2020; Bertello, Ferraris, Bernardi, & Bertoldi, 2022). For firms, this mechanism is considered fundamental for improving their innovation capabilities and competitiveness (Ardito, Petruzzelli, Dezi, & Castellano, 2020; Pihlajamaa, 2023).

Governmental agents have played an important role in guaranteeing the institutional framework for the establishment of open innovation and creating incentives for these initiatives (Jugend, Fiorini, Armellini, & Ferrari, 2020). These incentives can take the form of the creation of physical and institutional environments to support small firms, such as business accelerators, business incubators, and science parks, and providing public funding support to partnerships (Leckel, Veilleux, & Dana, 2020; Suhada, Ford, Verreynne, & Indulska, 2021), the establishment of objective rules to avoid opportunistic behavior (Mattos, Kissimoto, & Laurindo, 2018), and the establishment of intellectual property mechanisms, such as patent rights (Dahlborg, Lewensohn, Danell, & Sundberg, 2017; Suh & Jeon, 2019; Tukoff-Guimarães, Kniess, Penha, & Ruiz, 2021), to safeguard the rights of the partners involved (Nguyen, Huang, & Tian, 2023).

From the perspective of the knowledge flow, open innovation can be outbound when a firm transfers knowledge to another agent, inbound when it receives knowledge, and coupled when both activities are implemented simultaneously (West, Salter, Vanhaverbeke, & Chesbrough, 2014; Popa, Soto-Acosta, & Martinez-Conesa, 2017). These interchanges can be either pecuniary or non-pecuniary (Singh et al., 2021). Traditionally, the literature has considered open innovation efforts of firms to develop new products (Janeiro et al., 2013; Bäck, & Kohtamäki, 2015).

Organizations should balance inbound and outbound knowledge flows and consider what knowledge will be accessed externally (Sun, Liu, & Ding, 2020). Firms can establish partnerships with different types of agents,

including customers, communities, competitors, experts, non-governmental organizations, public institutions, and universities (Rayna, Striukova, & Darlington, 2015; Rauter et al., 2019; Ardito et al., 2020; Nascimento, 2021). However, the current literature does not consider the specific nature of external knowledge accessed by organizations (Cassiman & Valentini, 2016; Angelidou et al., 2022). In this case, it is important to consider the classification of the competencies of teams that create new technologies.

An alternative for better understanding the nature of external knowledge accessed through open innovation is using the concept of interdisciplinary and multidisciplinary knowledge (O'Cathain, Murphy, & Nicholl, 2008). Interdisciplinary teams involve individuals with competencies in adjacent knowledge fields that are intrinsically related (e.g., electronic engineering, and computer science; medicine and pharmacy), and multidisciplinary teams involve individuals of "**a priori**", not related knowledge areas whereas the knowledge can be combined for production of a new technology (e.g., computer science and medicine) (Nancarrow et al., 2013).

Universities have been seen as an important source of knowledge for firms (Villasalero, 2014; Wirsich, Kock, Strumann, & Schultz, 2016). In some cases, there is governmental support for establishing open innovation partnerships between universities and firms (Nascimento, 2021; Bertello et al., 2022), especially for partnerships with startups (Villasalero, 2014; Díez-Vial & Montoro-Sánches, 2016). These governmental incentives can produce positive regional effects (Cunningham, Lehmann, Menter, & Seitz, 2019) through knowledge co-creation (Dahlborg et al., 2017; Viana, Jabour, Ramirez, & Cruz, 2018). Therefore, collaboration between firms and universities involves two types of agents with different institutional logics, which can eventually lead to conflicts, but can also be positive in generating synergy between these agents with different competencies He, von Krogh, Sirén, and Gersdorf (2021).

Despite the broad investigation into open innovation activities that involve cooperation between firms and universities, researchers have focused primarily on the benefits generated for firms. Only recent studies have sought to examine the effects of open innovation in universities and the development of new scientific knowledge that is useful for society (Alexander et al., 2015; Huggins et al., 2020; Beck et al., 2022; Goebel, Losekann, Polla, Montenegro, & Ávila, 2024). This new area of investigation in the open innovation field is particularly important considering contemporary social and environmental challenges, as well as universities, can play a critical role in generating several benefits for society (Rauter et al., 2019; Shaikh & Randhawa, 2022).

METHODS

This study was implemented through qualitative research in a public Brazilian university. To obtain a picture of how this university has implemented open innovation, an academic unit was analyzed, it is dedicated to medical teaching, research, healthcare services, and the development of new technologies in the medical field, which is in line with recent studies about open innovation in the medicine context (Coccia, 2020). This university and the specific academic unit were chosen as research setting by convenience (Cooper & Schindler, 2013), due to its importance in the Brazilian context. The chosen university is one of the most important universities in this country, and the academic unit is recognized nationally as an excellent unit in providing activities in the medical field and has economic, humanitarian, and social importance.

Owing to the medicine unit, henceforth, the medicine development unit (MDU), corresponds to an important unit in the field of medicine in Brazil. It offers several courses, from undergraduate to PhD courses, also with pos-doctoral research. Besides the high level of inception of its researchers in the international scenario, this unit also develops new technologies related to the field of medicine that in several situations are protected through patents. MDU was founded in the 1940s decade and has played a central role in the development of an academic innovation ecosystem, which currently pertains to a university campus comprehended by other academic unities in the social and health sciences. Additionally, this unit also is related to a large hospital, a science park and other public foundations dedicated to offering health public services to the population.

Considering the purpose of investigating the open innovation initiatives in the context of MDU this research through analysis of 15 patents in the field of medicine deposited by this academic unit developed in partnership with other agents. Given the nature of the qualitative research as an instrument to better understand the configuration of the researched objects and the relations constructed between them, in this study the researchers seek to understand the main aspects of open innovation initiatives of MDU, considering the types of agents involved in these cooperative activities, the types of cooperation arrangements, as well as the nature of the knowledge and competencies acquired by this academic unit.

Data sources

This study was performed through the documental analysis, there were accessed the following types of documents: firstly, there were analyzed the complete list of 93 patents deposited by MDU from 1988 until 2020, whereas was verified that 41 patents were assigned uniquely by this unit, 37 assigned by this unit conjointly with other academic departments, and a public foundation of the same university, and 15 patents were created through the

collaboration with external organizations (Table 1). It was considered an open innovation initiative for those patents whereas MDU was assigned with other academic unities of other universities and external organizations. In this case, for each patent of this group, its content was screened, and their metadata were recorded.

Patent	Feature Outline
P1	Process for eliminating the antigenic and immunogenic fraction of hydrolyzates, protein to be used in the preparation of nutritional solutions.
P2	Case therapeutic agent, pharmaceutical compositions, and its use in the treatment of diseases caused by micro bacteria.
P3	An ophthalmos instrument, coupled to the 51x Lamp or Ocular Microscope, using the image to selectively measure the corneal curvature.
P4	Composition, concentrate, and aqueous liquid derived from, or complementary to, the herbaceous plant.
P5	New composition and/or obtaining process for treatment of diseases caused by micro bacteria.
P6	Herb vaccines (Irg6, 1R64), pharmaceutical composition for treating fungal or bacterial infections.
P7	Recombinant N protein that can be used as an antigen in ELISA and diagnostic kits for respiratory diseases in swine.
P8	A new oncoprotein tool, presented by the form of recombinant DNA for inducing apoptosis of tumor cells and its use.
P9	Preparation of molecules or fragments of recombinant polysaccharide under one of the polysaccharide structures in SBE.
P10	System for analyzing an aseptic commodity that can be used in training on the aseptic technique.
P11	Use of the protein *null* recombined to treat haemophilia (I).
P12	The patent refers to the development of a key-screw solidary coupling system for dental applications.
P13	Optical fiber for the construction of materials through the use of two co-extruded or stamped thin films.
P14	Use of viral vectors in the preparation of pharmaceutical compositions.
P15	Optical device for forming images and for the transmission of body cavities or channels through visual inspection or photography.

Table 1. The resume of patents screened in the research

In the second step of data recovery, the curricula of each participant of the 15 patents were accessed in the Lattes Platform, which is a Brazilian virtual platform that contains the curricula of Brazilian researchers with their main academic data, such as academic formation, publications, patents registered, among other data. For each inventor, it was verified the academic formation, the research areas where he performed research and technological development.

In the third step, it was verified the nature of the organizations that conjointly with MDU assigned the patents. The web pages of these agents were visited, and the nature of their operations was screened.

Coding and generation of theory

Based on the premises of multiple levels of data categorization (Corbin & Strauss, 1990; Linneberg & Korsgaard, 2019), after gathering the research documents, based on a research protocol with the main constructs of the literature – the organizations and individuals involved in open innovation agreements, and the nature of knowledge to create and disseminate a new technology – it was performed a first coding stage. This stage permitted to the authors identify the primary constructs, corresponding to the data and metadata of the documents, such as the names of inventors, academic formation and technological production, and names of organizations.

In the second stage, there were performed the codifications about, the types of organizations that participated with MDU in the development of new technologies, the knowledge of inventors, based on their curricula, the types of agreements according to the organizations that participated in each patent, the nature of the knowledge embedded in the patent, and the potential diffusion channels enabled to MDU through the types of a partner in a patent. In the third stage, the data instances coded priorly were clustered according to their similarity.

The codification process related above permitted the development of two levels of theorization. The first and second stages permitted the formulation of a general theoretical model that identifies several constructs that are related to the development of patented technologies in the university context, that transcend its specific research object. For example, inventors, patents, external organizations, diffusion channels, and the types of knowledge interchanged in an open innovation partnership. These constructs among others transcend the specific research setting and can be applied to other university contexts, reaching an important proposal in the construction of theory (Eisenhardt, 1989; Shepherd & Suddaby, 2016).

The codification performed in the third stage permitted to creation of a general picture of the specific situation of open innovation activities developed by MDU. So, it was possible to quantify the type of knowledge and arrangements present in the open innovation agreements of this academic unit with other agents. This result can be used in future to compare the performance of this unit with other academic unities in different contexts.

RESULTS

This research revealed two basic types of open innovation partnerships of MDU with other organizations (Table 2).

Patents	The new types of partners in the open innovation initiatives	Possible capabilities absorbed	Participants' areas of knowledge
P1, P2, P5	With a unique academic department of another university	Interdisciplinary knowledge	Biochemistry, Chemistry and Pharmaceutical Sciences
P11	With a unique academic department of another university	Interdisciplinary knowledge	Medicine, Cellular and Molecular Biology
P3, P9, P14, P12	With a firm	Multidisciplinary knowledge and market channel	Physics, Medicine, Biochemistry, Molecular Biology and Immunology, Basic and Applied Immunology
P4, P6, P7, P15	With a firm	Multidisciplinary knowledge and market channel	Biochemistry, Chemistry, Medicine, Basic and Applied Immunology, Biological Sciences
P10	With a public foundation	Multidisciplinary knowledge and social service channel	Mechanical Engineering, Medical Sciences
P27, P13	With a public foundation	Interdisciplinary knowledge and a channel for social service	Biochemistry, Medicine, Comparative Pathology

Table 2. The arrangements identified, its configuration and capabilities accessed through open innovation

Horizontal arrangements whereas MDU is associated with another academic unit of other universities. In this case, the partnerships occur mainly due to the complementarity of technical knowledge between researchers and inventors of different academic institutions. Vertical arrangements are those where the MDU established the co-creation of a new patented technology with an external organization, with a channel capable of diffusing a new technology for society. In this case it was identified the relation with firms, or public foundations.

Horizontal arrangements as a way to access complementary knowledge to create new technologies

It was verified several different institutional arrangements to access external scientific knowledge necessary to develop new technologies related to the 15 patents researched. The nature of the scientific knowledge accessed through open innovation initiatives was classified as interdisciplinary and multidisciplinary.

Owing to the access to interdisciplinary knowledge, it was verified a total of 8 patents, distributed in three configurations, three patents where MDU associated with external academic departments of other universities, in four cases, MDU associated with firms to develop new technology, and in one case it associated with a public foundation.

The access of MDU to multidisciplinary knowledge available externally resembles the access to interdisciplinary knowledge. In seven patents this unit accessed to multidisciplinary knowledge, with one partnership with another academic department, four partnerships with firms, and one partnership with a public foundation.

Regarding the partnership with firms, MDU is associated with one big firm that operates in pharmaceutical distribution, and the remaining cases with small and middle-sized firms. The public foundation with which MDU is associated is related to the development of health technologies and the offering of health public services.

The inventions developed with interdisciplinary knowledge involved the development of new composites in the pharmacy, and clinical analysis field (e.g., exams, haematology), while the multidisciplinary, involved the development of devices related to the medical area.

Vertical arrangements as a way to complementary knowledge to create and disseminate new technologies

The partnership agreements between MDU and external agents also suggest access to knowledge about the diffusion of technologies through public service channels and market channels. This research revealed that public service channels also can be used for disseminate technologies developed in the university context. This research identified two patents whereas MDU cooperated with a public foundation for the development of new technologies, through the potential access to social service channels and interdisciplinary knowledge. Among the technologies developed between the MDU and the public foundation are composites for the pharmaceutical industry and the treatment of cancer.

Owing to the partnerships of MDU with firms for the development of new technologies, it was verified the development of four patents with interdisciplinary knowledge and four patents with multidisciplinary knowledge. The firms that participated in partnerships with MDU account for professionals with scientific formation and experience in the development of products in the health field. Six firms participated in the development of the eight patents, where five assigned only one patent with MDU, while a firm assigned three patents. Of these six firms, five are small or middle firms located in the same geographic region of MDU, and one is a big company with unities scattered in the Brazilian territory.

Synthesis of the results

The application of the conceptual categories created through the screening of the literature permitted to identification of the specific aspects of open innovation activities performed by MDU in partnership with other external agents (Figure 1). Based on the compilation of data it is possible to state the following conclusions.

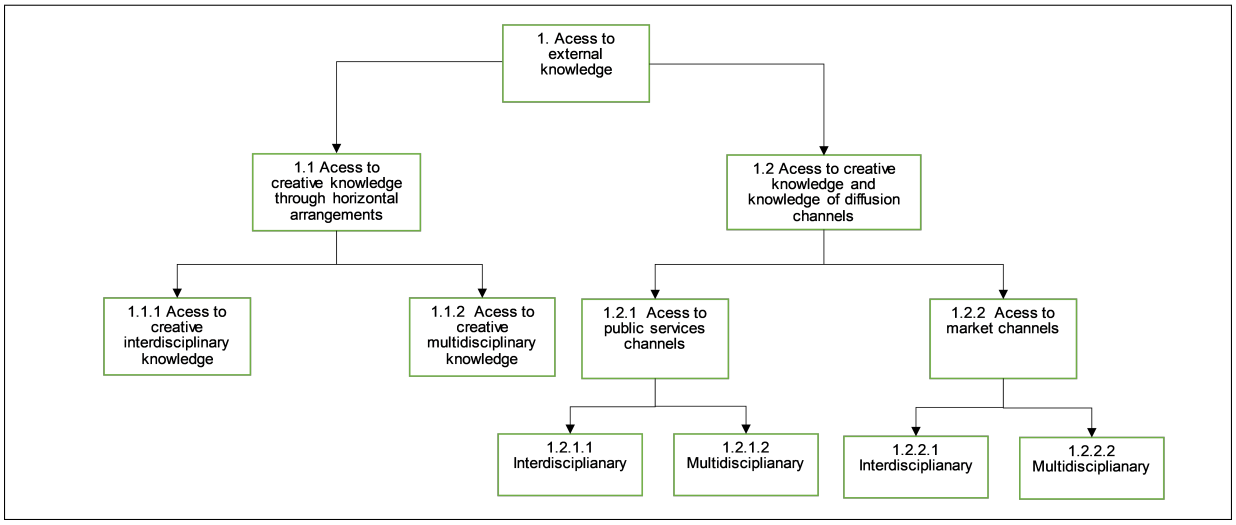

Figure 1. Synthesis of the types of knowledge and organizational arrangements of open innovation

An considerable balance was found in the access of external creative competencies, in eight patents the formation of teams, accounted for interdisciplinary knowledge, and in the remaining seven, accounted for multidisciplinary knowledge. With relation to the nature of the external organization with MDU established open innovation agreements, it can be noted that in most of the patents, eleven of the fifteen patents, the external organization has competencies, "**a priori**", not detained by MDU, that is, the direct capability of disseminate new technologies to society, through public services, in the case of the public foundation, or through market mechanisms, through firms. This situation suggests that open innovation partnerships are not only enacted to access external scientific knowledge but furthermore, to access knowledge related to channels for the diffusion of products and services based on new technologies for society.

DISCUSSION

Assuming a post-Shumpeterian perspective this article confirms recent authors (Urbinati et al., 2020; Bertello et al., 2022) showing that academic unities in universities can establish open innovation agreements to access external knowledge. On the other side, it also shows the possibility of access to knowledge about public service channels, as a possibility of diffusion of new technologies. Further, this article shows in detail how this process is based on two broad categories. First, it identifies the institutional arrangements used by an academic unit in a university, which reveals two general types of external agents, external academic units, which also are a repository of scientific and technical knowledge for the creation of new technologies, and in the other side, firms or public service foundations, that despite being a repository of scientific and technical knowledge, also have

knowledge related to the social behavior of their target audience and about how to disseminate new products and services to them. This finding complements the current view of the types of external agents present in the literature (Lopes & Carvalho, 2018; Rauter et al., 2019; Ardito et al., 2020) extending it to the university context, what is important to consider the possibility of diffusion of new technologies beyond the markets, through public services channels.

About the knowledge accessed externally by MDU, this article goes beyond the current view of the knowledge interchange of organizations through open innovation (Aliasghar & Haar, 2023), identifying and classifying the knowledge interchanged in the academic context. There were identified two broad categories, scientific knowledge, and knowledge of disseminated technologies for society. Still in this aspect, this research brings to the open innovation context, the concepts of interdisciplinary and multidisciplinary knowledge (Fong, 2003; Van Der Veft & Bunderson, 2005; O'Cathain et al., 2008; Nancarrow et al., 2013).

Considering the institutional logic of universities to develop research and new technologies and public foundations to offer public services to society, it is possible to infer that in addition to probable market incentives to disseminate technologies, which takes place through the association of universities and firms, the diffusion of technologies also can be an incentive to the values of contribution to society, what can be inferred through the association between universities and public service foundations. This finding is in line with Ribeiro and Shapira (2020) who consider the existence of not only private but also public values in innovation development.

In line with Greco, Grimaldi, and Cricelli (2017) and Leckel et al. (2020), who consider the importance of public funding in the context of open innovation, this article confirms the existence of public policies for the development of innovation in two forms, through the financing of operation of the public university research and the public foundations involved in the development of new technologies. Additionally, the register of patents between the academic department researchers through an intellectual property autarchy in Brazil also recognizes the support of the institutional structure for guaranteeing property rights, which is in line with the literature (Mattos et al., 2018; Grimaldi, Greco, & Cricelli., 2021; Nguyen et al., 2023).

Finally, the types of arrangements identified in this research, horizontal and vertical, the external agents with which the academic department can establish partnerships, external academic agents, public services foundations and firms, and the types of external knowledge accessed, scientific knowledge (interdisciplinary and multidisciplinary), and about the diffusion channels, through the market and public services, extends the existing literature about open innovation in the university context (Alexander et al., 2015; Huggins et al., 2020; Beck et al., 2022), presenting new categories of arrangements and knowledge accessed through open innovation partnerships between university's academic units and external agents.

CONCLUSION

This article analyzed open innovation initiatives in an academic department dedicated to the medical field in a public Brazilian university. It seeks to expand the current debate about open innovation beyond the predominant studies focused mainly on firms. From the perspective of the study of technological innovation, the article uses a post-Schumpeterian perspective, so, it assumes that is possible to disseminate technological innovation to society through not only market mechanisms, according to the orthodox perspective (Mehmood, Alzoubi, Alshuridecj, Al-Gasaymeh, & Ahmed, 2019; Devaraj, Wolfe, & Patel., 2020; Haeussler & Assmus, 2021), but also through public services.

As the main contribution article this article presents the types of organizational arrangements constituted between the academic unit studied and external agents, and the types of knowledge accessed externally. It permitted the identification of two categories of organizational arrangements for open innovation (horizontal and vertical), three types of external agents for partnerships (external academic units, public services foundations, and firms), and two types of external knowledge (scientific knowledge and about diffusion channels), that can be interdisciplinary or multidisciplinary.

As an implication to the theory, this article expands the current view about open innovation focused on the university context (Alexander et al., 2015; Huggins et al., 2020; Beck et al., 2022), and highlights the importance of typifying the knowledge accessed externally through this mechanism. As implication to the practice, the types of arrangements and knowledge identified can be used as an analytical framework to assess the extant open innovation relations in the academic units of universities, and as a prospective tool for planning possible arrangements for the development and diffusion of new technologies for them.

As a suggestion for future studies, this article can inspire the improvement of the proposed framework for the development of assessment tools for comparative analysis of the open innovation capability between universities. Considering that this research revealed that universities can disseminate innovation using market mechanisms or public services mechanisms, further research can combine qualitative and quantitative methods to identify the respective incentives for the development and diffusion of technologies through these two different channels.

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