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INTELECTUAL PROPERTY IN COLLABORATIVE RESEARCH AND DEVELOPMENT: THE CASE OF EMBRAPA

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Comunicamos que devido à pandemia do Coronavírus (COVID 19), o VIII SINGEP e a 8ª Conferência Internacional do CIK (CYRUS Institute of Knowledge) foram realizados de forma remota, nos dias **01, 02 e 03 de outubro de 2020.**

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Objetivo do estudo
We analyze the mechanisms relate to external Research and Development (R&D) collaboration in the agricultural innovation's context, where Intellectual Property (IP) plays a key role. We address the issue in IP rights relate to R&D collaboration with different external stakeholders by analyzing the Brazilian Corporation for Agricultural Research (Embrapa).

Relevância/originalidade
The systematic interaction of innovation agents and networks contributes significantly to the development of OI practices at EMBRAPA, combining skills, efforts and developing innovations that could not be created exclusively within the organization, but it is important to invest and strengthen the culture of IP, in all parties involved in the collaborative phase of the project and in the patenting process.

Metodologia/abordagem
This study is characterized as qualitative. The structure of this research was built in three stages, as follows: theoretical framework, secondary data collection and data analysis.

Principais resultados
The interaction of innovation agents, ideas and networks and also enabling a collaborative innovation environment, prospecting and implementing strategic partnerships and alliances, sharing skills, capabilities and infrastructure - significantly contributes to the development of OI practices, regarding IP policies and strong policies.

Contribuições teóricas/metodológicas
Such interactions demand protection systems, IP rigid practices and consolidated policies among Embrapa and its stakeholders involved in the innovation process. Besides that, Embrapa can be considered an outside-in and pecuniary organization.

Contribuições sociais/para a gestão
Through the evidence identified in the research, several opportunities in open innovation practices were already being explored by Embrapa to reach new technologies and improve its outside-in open innovation model.

Palavras-chave: inovação aberta, pesquisa e desenvolvimento colaborativos, propriedade intelectual

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Theoretical / methodological contributions
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Social / management contributions
Through the evidence identified in the research, several opportunities in open innovation practices were already being explored by Embrapa to reach new technologies and improve its outside-in open innovation model.

Keywords: open innovation, collaborative research and development, intellectual property

1 Introduction

When alliances are formed, they co-evolve with the partners and environment (Das & Teng, 2002); and according to Smart et al (2019), in an age with a growing body of scientists pushing open ideals, the trend towards greater openness and exploitation seems inevitable. For them, the development of a generative link between open approaches to science and innovation adds to the ongoing debate about the changing nature of knowledge production regimes. Some opportunities in the Open Innovation (OI) initiatives and scenario were identified by De Silva & Wright (2019); they can be exploited to reach new outcomes when combining physical resources, people, knowledge and skills, capabilities, technologies, finance, markets and networks.

Alongside with the opportunities that Research, Development and Innovation (RD&I) joint efforts might bring, there are potential risks that companies face when using this approach. The collaboration with other actors in research and development activities may increase the demand for knowledge protection. Organizations and individuals engaging in joint innovation projects fear the loss of control with respect to crucial resources, ownership of intellectual property rights and the risk of opportunistic behavior on the part of external partners. (Ahn et al., 2019) In order to manage and to secure this relation, intellectual property rights among other forms of protection are needed (Olk & West, 2019).

Defense mechanisms are used to ensure that all parts safeguard their knowledge and benefit from the outcome of this process (Henttonen et al., 2015). Appropriability issues are among the problems faced within an open flow of knowledge among different players: customers, suppliers, competitors, universities, and research organizations (Laursen and Salter, 2014).

In this article we analyze the mechanisms relate to external RD&I collaboration in the context of agricultural innovation, where Intellectual Property (IP) plays a key role. This correlation is still not completely clear, further studies are needed in order to clarify the extent of IP's importance, and how it encourages innovation (Buainain et al., 2015). We address the issue in intellectual property rights relate to RD&I collaboration with different external stakeholders by analyzing the Brazilian Corporation for Agricultural Research (Embrapa).

2 Theorical Background

Why should we care about agricultural technology in Brazil? And what Embrapa has to do with it?

According to Embrapa, in 2016, agribusiness generated 23% of Gross Domestic Product (GDP) and 46% of exports. In 2017, the sector was responsible for 19 million employed workers. Agribusiness and services employed, respectively, 4.12 million and 5.67 million people, while 227.9 thousand people were employed in the agribusiness inputs segment (Embrapa, 2019). The combination of technology, knowledge, and absorption capacity is fundamental for the transformation of Brazilian agriculture. The last 50 year have been the scene of technological advances of this sector. The country went from net food importer in the 1960s to a strategic producer in 2014 (Vieira, 2014). Brazil has increased rates on agriculture productivity (Ministério da Agricultura, 2017), most of it due to technology, 58,4% of agricultural production growth in Brazil comes from technology, while 15% from land, and other 15% from labor (Ministério da Agrucutura, 2017).

Innovative activities in the agricultural sector in Brazil relies considerably on Embrapa's accumulated technological capabilities (Figueiredo, 2016). The company has a leading role in

agricultural technology in the country, and it is recognized as one of the most important public institution for research and development in the world (Buainain et al., 2015). Created in 1973 inspired by four principles: diffusion of modern technology; activities' planning; coordination with external environment, and a multidisciplinary approach on research and development (Rodrigues, 1997). Throughout its forty-seven research units spread out in Brazil (Lopes et al., 2012), Embrapa works with network establishment - partnerships and arrangements among public and private sectors that foster agricultural innovation in Brazil. (Contini & Andrade, 2013, p. 577)

From closed innovation to OI

In closed innovation, RD&I is conducted in closed doors, eventually, some specific knowledge can be sought at a university or research institute, however this collaboration is timely and surrounded by careful information confidentiality (Chesbrough, 2003). In OI, there is systematic interaction with external actors - universities, research institutes, other companies, and innovation networks. Within this type of interaction, it is possible to combine skills and efforts to generate innovations that could not be created exclusively within the organization (SLUSZZ, T. et al, 2013).

According to Nambisan et al (2018), OI involves a shift toward more open and distributed models of innovation, and constitutes a mechanism for reducing research costs, spreading risks, and commercializing innovations more rapidly. Dahlander and Gann (2010) clarified the definition of openness and its influence on the innovation capacity and appropriation of the resulting benefits by the companies, and classified OI in four processes: two outside-in processes - search and acquisition - and two inside-out processes - disclosure and sale. Chesbrough (2006) classified OI into outside-in - where the firm's limits are open enough to allow external actors to participate on innovation processes of the main organization - and the inside-out, which is the opposite path, the knowledge goes from inside companies' borders to the external environmental.

Chesbrough & Brunswicker (2013), Chesbrough (2015), Bogers, Chesbrough et al. (2018) categorize OI as inbound (outside-in) and outbound (inside-out) OI. Chesbrough & Brunswicker (2013) combined possible financial flows and directions of OI. Figure 1 summarizes the forms of OI practices in large companies.

Private, public and nonprofit organizations *"need to be linked to other stakeholders to get a more complete picture of how innovation can be done more efficiently and effectively"* (Bogers, Chesbrough et al. 2018). OI is an answer to this link and can impact performance outcomes, however, to achieve this goal, changes inside the organization are needed. In this article, we use Chesbrough & Bogers (2014) concept of OI: *"a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organization's business model"*.

Our purpose is not to confuse neither to compare OI with open strategy, which is already clarified by Dobusch et al (2017). Open strategy builds on the notion of OI, the process by which corporations increasingly innovate by pooling knowledge and ideas with communities of external agents, e. g. users, business partners and universities (Whittington et al., 2011). This interactive process involves inbound and outbound knowledge flows, *"with mainly complementary partners through alliances, cooperation and joint ventures during which give, and take are crucial for success"* (Enkel, Gassman & Chesbrough, 2009, p.13). Thus, Stanko et al (2017) contributes saying that coupled OI refers to an interactive mode of knowledge

flowing into and out of the organization involving collaborative effort with innovation partners.

Firms need to build competitive advantage in regimes of rapid change (Teece et al, 1997) and anomalies (Chesbrough & Appleyard, 2007). Important responses to this scenario need to

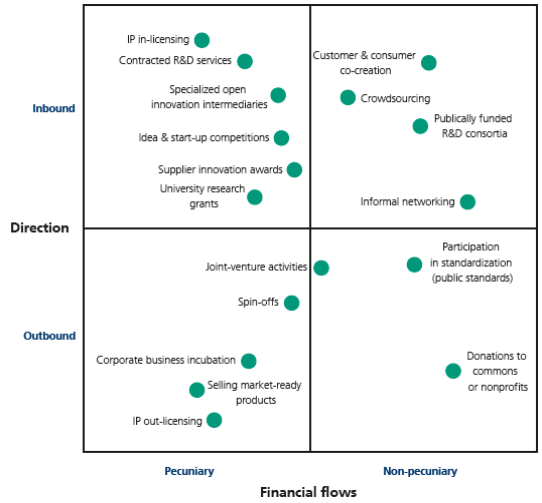

Figure 1: Modes of OI. Source: Chesbrough & Brunswicker, 2013.

be elucidated, for both managers and researchers. It is *"the concept of open source development and similarly inspired ideas such as OI, the intellectual commons, peer production, and earlier notions of collective invention represent phenomena that requires a rethinking of strategy"*, as stated by Chesbrough & Appleyard (2007). Collective actions, value creation, value capture and value co-creation are other themes related to OI that were also discussed by Vargo & Lusch (2004), Payne, Storbacka & Frow (2008), Sullivan et al (2011) and Chesbrough et al (2018).

Openness determines the trade-off between adoption and appropriability and also influences the development trajectories that technologies follow over time: openness can stimulate innovation by combining the efforts of a large and diverse pool of complementary firms, leading to increased product diversity and better matching of products and consumer preferences (Almirall, E., and R. Casadesus-Masanell, 2010). Chesbrough et al (2018) reveals that *"the core tenet of OI research is the wide distribution of useful knowledge, such that no individual or organization has a monopoly on useful knowledge."* Also, for Lauritzen & Karafyllia (2019), "if firms engage with OI paradoxes, they will combine distinct control and openness efforts with integrative efforts within and across the key themes of attracting, incorporating, and commercializing". They propose a paradox thinking to resolve ongoing controversy about the potential of external collaboration for innovation.

Kankanhalli et al., (2017) argue that there are relevant variations among public and private organizations regarding OI processes. In terms of value, the private sector focuses on adding value in terms of increase profits, while the public sector might also want to add value, however, focusing in benefiting the society. The attitude towards the society of public companies can also explain how they behave in terms of intellectual property rights.

Although OI is connected to knowledge sharing, the dissemination of this information can increase the risk of imitation, emerging the need of knowledge and technology protection (Ranängen e Zobel, 2014; Holgersson, Granstrand and Bogers, 2018; Dziallas & Blind, 2019).

Intellectual Property

Knowledge is an important resource for business, strategy, RD&I. Its protection has

become legally accepted by the Intellectual Property Rights (IPR) (Wang, Chai, Subramanian; 2015). The World Intellectual Property Organization (WIPO) describes intellectual property rights as human effort and creativity resulting from people's inventive ability, recognition or reward (WIPO, 2019). Kalanje (2006) argues that IPR are unique creations resulting from human creativity and inventiveness, which generates added value. For Graham and Mowery (2006), intellectual property rights determine the new knowledge coming from the human minds and limited its attributes, forming efficient licensing markets.

Harrison, Sullivan and Davis (2012) describe the main types of property rights: trademarks, copyrights, and trade secrets. The knowledge embedded in new inventions creates new sources of corporate profitability (Carneiro, 2000). WIPO, in partnership with each nation, regulate the intellectual property standards (Vasconcelos, Silva; 2019). In Brazil, the National Institute of Industrial Property (INPI) is responsible for the national intellectual property regulation. The INPI is a federal authority created in 1970, with the aim of stimulating innovation and promoting the technological and economic development of Brazil, through the Protection of Industrial Property (INPI, 2019). INPI separates IPR into three areas: industrial property (corporate patents), copyright (personal, scientific and digital) and sui protection (integrated circuit topography, vegetable farming and genetic resources resources).

Intellectual property rights management is a way of qualifying companies' rights and copyrights, which can be used to maximize company profitability (Berman, 2009). The globalization process, the emergence of new technologies and the constant economic changes among countries increased the interest in IPR, as it allows the ownership of technology and information property, a source of royalty's generation by the exploitation of patents and trademarks. (Candelin-Palmqvist et al., 2012; Gentleman, Joia and Veenstra, 2016; Pereira, 2011).

From close to OI: challenges to intellectual property management.

Several companies have moved from closed innovation towards open and collaborative types of innovation (Gassmann et al., 2010). Research and development collaboration with a variety of players has risen (Tether, 2002), and there are several studies revelling positive effects of external collaboration on firm knowledge and innovation outputs (Arranz and Arroyabe, 2008; Henttonen et al., 2015, Mandelman e Waddle, 2019). However, external collaboration also involves possible downsides.

When innovation happens in closed doors, focus and control are internal, whereas and OI model demands companies to set their boundaries free (Dahlander and Gann, 2010). However, to make this transition from a close to an OI, companies are faced with diverse challenges. These changes demand focus of innovative firms on intellectual property and its management. There are challenges encounter by firms regarding IPR, which are critical to enable OI approaches. Governance, management of cooperation practices, and intellectual property issues are some of them (Enkel, Gassmann and Chesbrough, 2009).

Acquisition and commercialization IP in technology markets contrast with traditional processes of closed innovation, but in many cases technology transfer can be as expensive and time-consuming as performing RD&I internally (Nelson, 2006; GALASSO, 2020). The OI paradigm recognizes that a company can derive value or income from its innovations (through licensing or other forms), which encourages it to produce them. However, such payments are contrary to the expectation of what many consider to be an "open" form of innovation, in which a shared novelty should be available at no cost (West, 2006). These opposing views have resulted in major controversies over intellectual property policies. There seems to be a misperception that OI means that everything will be in the general public domain, or that there

is no concern for intellectual property (IP). It is just the opposite in most business models. With the proper IP management, the company decides whether to release or protect its results, capturing value from its IP rights, and identifies external knowledge that may be useful to it (OECD, 2008).

Al-Aali and Teece (2013) consider new elements for IP strategy that managers should consider. The joint use of copyrights, trade secrets, and patents. The inevitability of external search for innovation (OI). Options now available: selling products, licensing the IP or even doing both. The IP appropriability strategies and the shift of RD&I decisions from invention funding to a model of evaluating the accessibility of complementary assets.

There is an OI dilemma, which is reorienting the understanding regarding intellectual property protection. In one hand, there seems to be scepticism about spreading internal knowledge and collaborating with unknown partners, and in the other, intellectual property needs to be disclosed so cooperation is possible (Brem, Nylund and Hitchen, 2017). Schumpeter (1942), argued that entrepreneurs should have a monopolistic control over their creations, this would motivate them to innovate. In a free environment, without knowledge protection, inventors would be in disadvantage; thus, while they spend money and time to create new knowledge that could be copy at low costs by competitors. The protection is, therefore, a sort of return on investments made to innovate.

When it comes to OI, there is a concern about IPR. According to Chesbrough (2006) and Chesbrough & Chen (2013), IPR enables knowledge transfer, while for other scholars IPR can hamper openness once knowledge is not widely available (e.g. Von Hippel and Von Krogh 2006). Another important aspect of this dilemma is the importance of intellectual property rights when it comes to wiliness to cooperate. According to a study conducted by Hagedoorn, J., & Ridder, A. K. (2012) a great percentage of interviewed managers would not be inclined to collaborate, or share their inventions with others, if their activities where not safeguarded by IPR.

3 Methodology

From the research objective, this study is characterized as qualitative. Denzin & Lincoln (2006), emphasize the variety of research of this nature, we opted for the descriptive basic qualitative research. For Mariz et al. (2005), Merriam (2008), although this strategy presents a generic perspective, they correspond to the qualitative research paradigm. In this strategy the objective is the understanding of phenomena, identification of patterns, processes and the perspective of individuals involved (Merriam, 2002). In this way, the availability of concrete and reliable secondary data is essential to achieve the expected results (Pereira & Oliveira, 2014).

The structure of this research was built in three stages, as follows: i) theoretical framework, ii) secondary data collection in public documents, reports and manuals, and ii) data analysis. The first stage aimed to understand the context and scenario of OI and intellectual property in Brazil related to the agricultural sector. To this end, study was conducted related to OI, agricultural technology, and intellectual property rights. The second stage is the secondary data collection of documents and evidences that can provide information about Embrapa's OI and Intellectual Property policies.

The results were analyzed in the last stage of the research, called data analysis. The interpretation of the data was performed in a descriptive way, aiming to bring evidence about the practices of OI and intellectual property in the context of the case study.

4 Data Analysis

The analysis of the documents allowed for the unfolding into topics, starting from Embrapa's strategic planning, its objectives and perspectives, as well as OI as a key element. According to OI policies, some initiatives were detailed below, such as Business and Technology Showcase, Hackathons, Joint Calls, Labex Embapa program, Open Soy Innovation, PROETA, among others.

Subsequently, the documents related to intellectual property were analyzed, when in discussion with other stakeholders. Embrapa's patent portfolio, patenting and filing process, costs of registration, details of patent filing abroad, confidentiality between the parties and details on information protection during the process were described.

Embrapa's OI strategy

Embrapa's Strategic Map is divided into five main perspectives: i) bases for action, ii) institutional management, iii) Research, Development and Innovation (RD&I) challenges, iv) RD&I management, and v) Impact axes, which should drive its strategy until 2034:

i) Bases for action involves strategic intelligence in order to maintain RD&I planning and management aligned to trends and the context the company is in;
ii) Institutional management includes governance and institutional development;
iii) RD&I management is related to the management of research and development, technology transfer and technology business;
iv) Challenges of RD&I is a section that guidance company's actions towards the plan and execution of RD&I projects;
v) Impact axes are associated with Embrapa's role in the development of the Brazilian agricultural sector as well as its society.

One of the main focus of the strategic map for 2034 is to expand networking and relationships with national partners by *"developing innovative mechanisms and models of interaction and association with the public and private sectors, with priority for OI models"* (Embrapa, 2015, p:16. Translated by the authors). OI is, therefore, part of Embrapa's strategy planning for the next years.

As stated at Embrapa's Business Plan and Strategy - an instrument that communicates to stakeholders how investments will be applied throughout the year - OI as a key element to foster Research Development & Innovation. In order to promote OI and Digital Transformation, the company should build a favorable environment for entrepreneurship. Not only should Embrapa maintain its strategic partnerships with corporate areas, it should get closer to innovative ecosystems and to start-ups potentially able to absorb and improve the technologies developed by the company. The plan also highlights the different fronts for innovation mainly, *"open science and innovation, open data and new business"* (Embrapa, 2019, p: 37. Translated by the authors).

Embrapa's Innovation Policy from 2018 defines OI as innovation or improvement in production and processes engendered in partnership with other institutions, in order to increase efficiency and reinforce value added. The same document specifies that the company is going to promote OI throughout the connection between people and ideas, by fostering a collaborative innovation environment, prospecting and implementing strategic partnerships and alliances, sharing skills, capabilities and infrastructure to optimize the flow of technology-based innovation to the market and society, in Brazil and abroad. It also indicates that the actions towards

OI are developed by the company's Technological & Innovation Center (Núcleo de Inovação Tecnológica).

The company centers its efforts on partnerships with public and private institutions, national and international organizations to carry out programs, projects and joint technology research and development activities, products, processes or services (Embrapa, 2018). In order to foster OI through entrepreneurship, Embrapa has developed a Business and Technology Showcase (Negócios e Vitrine de Tecnologias), focused on the innovation ecosystem, namely to aggrotech startups, and Hackathons - *"problem-focused computer programming event, as well as a contest to pitch, program, and present instances of prototype digital innovation"* (Bricose & Mulligan, 2014, p:1). Embrapa promotes Hackathons with focus on the application of information and communication technologies to resolve agricultural sector problems (Romani, et.al, 2018).

The company has instruments to foster scientific collaboration, for example, the program Joint Calls (*Chamadas Conjuntas*), which allows research institutes to work together in researches of common interest. In addition, it has a strong international network. Throughout the program Labex Embrapa, it has been possible to foster international research cooperation since 1990. Within this initiative, researchers from Embrapa have been allocated in research and development centers across the globe, which has been an important aspect to share knowledge and develop new technologies.

Another program under consideration is Soy OI, launched in the last two months of 2019 (ref. Embrapa, 2019, news 48107774). The program starts with a public call for selection of startups and entrepreneurs interested in developing OI projects for the soy production system. The focus of the initiative is to bridge experiences and projects between Embrapa, with its expertise in soybean culture, and startups and entrepreneurs with their innovative ideas in digital technology applied to agribusiness and who are familiar with methodologies, processes and services available via Information and Communication Technologies (ICTs).

Partnerships with large agribusiness companies were signed with the objective of expanding Embrapa's importance in agriculture and boost the availability of technological solutions for Brazilian farmers. The company has partnership agreements with BASF, Syngenta and Dow AgroSciences for joint technology development. Technical-scientific cooperation projects, currently formulated in an OI system, led to the integration of technological development teams, allowing the creation of different models of seed, its distribution, and marketing. (Lopes et al. 2012).

Using OI as a strategy and seeking solutions for the Agricultural production system, Embrapa has structured itself through relationship networks that positively influence production systems through the transfer of new technologies. The PROETA (Agribusiness Incubation Program) was created in partnership with BID / FUMIN, in 2001; the program stimulates the generation of value to agricultural products and strengthens the market with technologies that impact the competitiveness of Brazilian agribusiness (Sluszz et al. 2013). According to Sluszz et al. (2013), the incubation process at PROETA is developed through the union of three main parts: Embrapa, partner incubators, and entrepreneurs. Each actor develops its activity in the process, contributing to the development of new companies in the agricultural technology area.

Together with the development of OI strategies, Embrapa Florestas has expanded its innovation network by establishing relationship networks in projects with several partners. It is also worth mentioning that Embrapa Florestas has in MP2 (Macroprogram 2) fourteen researches responsible for stimulating OI practices (Embrapa Florestas, 2017). By encouraging

the OI network, Embrapa Florestas contributes to the restructuring of its value chain and reduces the impact on stakeholders (Otto et al. 2009). Chart 1 summarizes the IO activities developed by Embrapa

PROGRAM	DEFINITION
Joint Calls	Allows research institutes to work together in researches of common interest.
Labex Embrapa	Allocation of researchers from Embrapa in RD&I centers across the globe to share knowledge and develop new technologies
Soy OI	Public call for selection of startups and entrepreneurs interested in developing OI projects for the soy production system.
PROETA (Agribusiness Incubation Program)	Stimulates the generation of value to agricultural products and strengthens the market with technologies that impact the competitiveness of Brazilian agribusiness
Embrapa Florestas	Program with fourteen researches responsible for stimulating OI practices
Partnerships	with large agribusiness companies with the objective of expanding Embrapa's importance in agriculture and boost the availability of technological solutions for Brazilian farmers.
Technological & Innovation Center	Promote OI throughout the connection between people and ideas, by fostering a collaborative innovation environment.

Chart 1: Summary of OI Embrapa programs

OI and Intellectual Property at Embrapa

Embrapa defines Intellectual Property as *"information or knowledge that can be incorporated at the same time into an unlimited number of copies of an object, anywhere in the world, and not to the copied object itself"* (Embrapa 2014, p11). The OI initiatives described so far can result in patenting, protected and recognized nationally and internationally. At Embrapa, the registered technologies cover different technological fields and include sustainable solutions to contribute to the Brazilian agricultural sector, some of them also applicable to human health. The analyzed documents highlighted that patenting is an important strategic tool for Embrapa's value creation, as it promotes technological, economic and social development, as well as keeping up with the technological trends under development (Figueiredo, Macedo & Penteado, 2008).

The patent option is also motivated by the financial return of the technology's in terms of patenting and maintenance costs. To evaluate this potential, Figueiredo, Macedo & Penteado (2008), indicated that Embrapa uses evaluation methods in order to estimate the financial return that a patent may result from commercialization or licensing. In addition, legal, technological, market, time, and possible variations in technology are analyzed.

The patent portfolio is divided into the following categories: i) Vegetable Technological Input; cultivar-related solutions, compositions, methods, devices, semiochemicals and biologicals applied to plants; ii) Animal Technological Input; feed, drug, genetic and biological solutions for use in animals and humans; iii) Plant Biotechnology; solutions relating to biotechnological components and methods applied to plants; iv) Animal Biotechnology; solutions related to biotechnological components and methods for use in animals and humans; v) Nanotechnology; solutions related to the agricultural and related sector through the application of nanotechnology; vi) Agroindustrial processes; solutions related to the development and improvement of agro-industrial processes; and vii) Equipment and implements, equipment-related solutions and implements for the agricultural and related sector.

Company policies state that initially all patents must be applied for in Brazil. In cases of patenting in other countries, possible direct and indirect returns, exploitation of new technology over time, as well as even more stringent market validation should be considered.

The patenting process

The decision on patenting a technology at Embrapa (Figure 2) involves those responsible for the new technology, intellectual property technicians, and its validation in the market. According to Embrapa's patent regulations, the patenting process begins when the author of the new technology investigates in patent documents and other sources, information about the area of technology he intends to claim. Next, the inventor requests the Technology Prospecting and Evaluation Sector (SPAT) to qualify the technology, which will verify the suitability of the technology to the requirements of novelty and inventive activity on a bibliographic and patent basis, as well as verify the applicability through market research.

Once the application meets the INPI's evaluation criteria, the patent is granted and it is possible to directly market the technology, sell or license it. Preferably, Embrapa opts for licensing. The ownership of registered patents is always attributed to Embrapa. The company adopts co-ownership of a patent in cases where an invention is developed with the participation of external authors. The percentage share in the ownership and financial benefits of the patent is defined by the percentage each author exercised in the elaboration process of the invention.

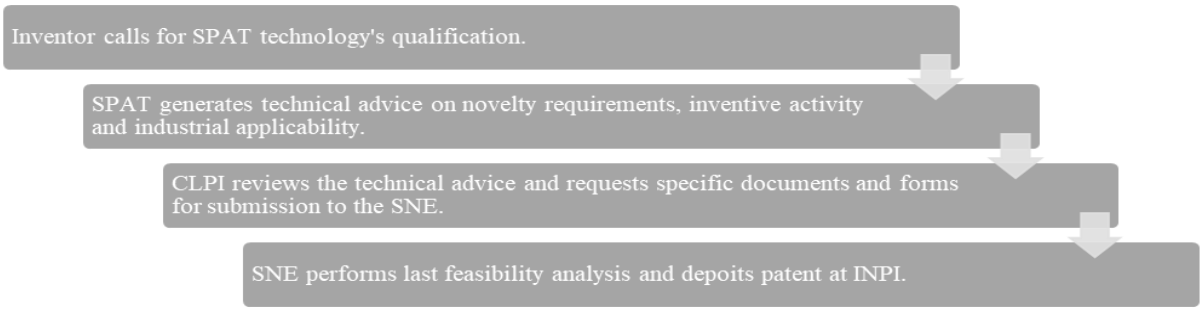

Figure 2: Summary of Embrapa's technology patenting process

Filing of Patent Application Abroad and Confidentiality

If Embrapa decides to file the application abroad, it will have up to 12 months from the filing date of the patent application in Brazil. According to Figueiredo, Macedo & Penteado (2008), this period guarantees the priority of the invention or utility model over any patent application of the same subject, filed during that period, in the country(ies) in which the recording was made. For example, if Embrapa's application was filed in Brazil on 3/1/2004 and then filed in the United States of America on 1/1/2005 (within the 12 month priority period), no patent application of the same invention filed between 3/1/2004 and 3/1/2005 may void the novelty of Embrapa's application, even if the patent applicant is a US company. More than that, the patent in the United States should be granted to Embrapa and not to the US company.

Figueiredo, Macedo & Penteado (2008) point out that in addition to being careful not to publish and not to comment to third parties - hastily and in advance the information obtained - it is important, for security reasons, that all parts who have access sign a confidentiality agreement. This term is a legal instrument used in case of breach of confidentiality. Another strategy adopted by the company is to record activities developed and results achieved by the company in minutes or laboratory book, which are pen-written and dated for legal value.

More Protection Required

An example provided by Figueiredo (2017) is *Pequi*, a tree specie, which 94% of national and international publications about it are Brazilian. However, in relation to patents, only 58.8% of the applications filed worldwide claiming the use of this plant species are from Brazilian institutions. An INPI study showed that of the Brazilian-origin patent documents (58.8%

of total applications), 50% of the cases are pending, 40% were filed, 5% were dismissed and 5% were extinguished; so far, no patent has been granted. Figueiredo (2017) found that while there is a strong partnership in research on *Pequi*, the same is not true for patenting; thus, only 8% of applications are under common ownership. Of the patent applications related to Pequi, 47% were filed by individuals, 38% by companies and 15% by research institutions.

5 Conclusions

We analyzed public documents that indicate policies and initiatives already implemented to promote OI at Embrapa. The company follows the trend observed by Smart et al (2019) and promotes OI by connecting people and ideas, enabling a collaborative innovation environment, prospecting and implementing strategic partnerships and alliances, sharing skills, capabilities, and infrastructure. Such strategies facilitate innovation in a more efficient and effective way, both at Embrapa and its partners (Bogers, Chesbrough et al. 2018) and corroborate with Figueiredo (2016), since they highlighted Embrapa develops innovative activities in the agricultural sector in Brazil. Thus, the company creates possibilities to generate greater competitive advantage in a rapidly changing environment, as argued by Teece et al (1997).

The initiatives already implemented for OI are diverse, from promoting entrepreneurship to increasing international research and development. The company focuses its efforts on partnerships with public and private institutions, national and international organizations (Embrapa, 2018). The tools for promoting OI through scientific and international collaboration are the Joint Calling Program (Joint Calling) and the international Labex program. Embrapa's international collaborative laboratories (LABEX) are an initiative to increase international presence and a source of knowledge acquisition through the interaction of researchers and modern shared infrastructure. In addition, Embrapa has also recently launched programs aimed at entrepreneurship, the Business and Technology Showcase and Hackathons are the latest initiatives in this area. These initiatives are in line with De Silva & Wright (2019) as they combine physical resources, people, knowledge and skills, capabilities, technologies, finance, markets and networks for best results.

Embrapa's OI initiatives are permeated by intellectual property issues, where patenting stands out as the main form of protection adopted by the company. The dilemma between OI and IP pointed by Brem, Nylund and Hitchen (2017) is also observed in Embrapa: on the one hand, the need for the company to share its technologies with partners to provide cooperation, and on the other skepticism about the dissemination of internal knowledge. To manage and safeguard of this relationship, Embrapa maintains ownership records of its technology activities, as suggested by Olk and West (2019). Patenting is the main tool used by Embrapa to protect its technologies and there is an extensive process that involves several departments and collaborators during the registration process.

According to Carneiro (2000), Figueiredo, Macedo and Penteado (2008) and Berman (2009), Embrapa patenting is also seen as a source of profitability and before starting the patent process, the company uses evaluation methods to analyze the potential financial return of the patent, as well as possible forms of commercialization or licensing. Where new technology is collaborated, costs and profits are divided according to the percentage of each inventor or company participating in the development of the technology. Reducing costs, according to Nambisan et al (2018), is a part of a mechanism when the approach is about open and distributed models of innovation; and sharing profits arising from new inventions is a topic previously quoted by Carneiro (2000).

Embrapa's protection strategies also act in line with Henttonen et al. (2015) and Wang, Chai, Subramanian (2015) when using legal documents of confidentiality agreements and written records of meeting minutes and activity results. Confidentiality is also an important topic stated by Chesbrough (2013), and Embrapa has some initiatives to guarantee that the process is secure until the end of the patenting registration.

From the OI strategies and the mechanisms of protection of intellectual rights found, it is evident that the actions taken by Embrapa basically permeate aspects of financial results. Governance practices and management of cooperative activities (see Enkel, Gassmann and Chesbrough, 2009) are still challenges to strengthen the intellectual property culture in the various stakeholders who participate in the patenting process (producers, educational and research institutions and small businesses). The link with these other stakeholders and mutual efforts are essential to achieve efficient and effective innovation (Bogers, Chesbrough et al. 2018), allow unique creations considering IPR and bring added value to all parts (Kalanje, 2006).

Chesbrough & Brunswicker (2013) also confirmed on their studies that there were no reports of abandoning OI practices. This also happened to Embrapa; there was no evidence of any initiative that has been left behind; also, using their classification of modes (Figure 1), we can pinpoint which quadrant Embrapa fits better. Considering the initiatives already described (e.g. Business and Technology Showcase, Hackathons, Joint Calls, Labex Embapa program, Open Soy Innovation, PROETA) and intellectual property documents and policies, Embrapa can be classified as an organization with pecuniary activities. Thus, its initiatives expect rewards and compensations - accessing or revealing information; and no information is communicated if there is no protection.

Besides that, Embrapa has a solid Strategic Map until 2034, with strong goals, directions and focus, all of them well established. Considering this, the company has an outside-in and inbound orientation. Its efforts of Research and Development, OI, Joint initiatives, are mainly focused to achieve its intended strategic goals.

Through the evidence identified in the research, several opportunities in OI practices were already being explored by Embrapa to reach new technologies and improve its outside-in OI model. Noteworthy are the Business and Technology Showcase, and Hackathons, which encourage the application of information and communication technologies to problems in the agricultural sector. Breaking across geographic barriers, the company established a strong international network through the program: LABEX Embrapa, promoting international research cooperation, resulting in the development of new technologies. Both partnerships increase the importance of Embrapa in agriculture and the availability of technological solutions for Brazilian farmers.

The authors found that the process of generating new technologies at Embrapa is treated as a strategic inbound orientation. Through partnerships with public and private institutions in a collaborative innovation environment, the company has designed to improve product and process development by providing qualified technological services to society, prioritizing its internal goals and strategic planning.

Embrapa’s OI initiatives result in patenting, which are registered covering different technological fields with sustainable solutions to contribute to the Brazilian agricultural sector. Patenting is an important strategic tool for Embrapa's value creation, considering technological, economic and social development.

Collaboration with other institutions in Embrapa’s research and development activities has stimulated the growth of agricultural technologies through OI practices, considering the demand for knowledge protection through intellectual property. To manage and ensure the

protection of resources involved in collaborative innovation projects, intellectual property plays an important role, which has been used by the company as defense mechanism, ensuring that all parties safeguard their knowledge and benefit from the outcome of this process, mitigating issues of appropriateness which might arise within an open flow of knowledge between different agents (internal and external).

In short, the systematic interaction of innovation agents and networks contributes significantly to the development of OI practices at EMBRAPA, combining skills, efforts and developing innovations that could not be created exclusively within the organization, but it is important to invest and strengthen the culture of intellectual property, in all parties involved in the collaborative phase of the project and in the patenting process.

Further research could advance the analysis by gathering primary data through interviews and questionnaires. Additional analyzes could lighten the correlation between intellectual property rights and RD&I collaboration in different circumstances (e.g. different industries, firms of different sizes, or international markets). We analyzed an isolated company with focus solely on the agricultural sector in Brazil, therefore it could be useful to understand how other sectors works, as well as differences between industries. It would also be valuable to understand the role of intellectual property in international research and development projects and its consequences. A longitudinal study could also be useful to comprehend the evolution and possible outcomes in research and development collaboration over time.

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