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Baseggio Crespi, Tatiane; Rezende da Costa, Priscila;
Scariot Preusler, Taísa; Silveira Porto, Geciane
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The alignment of organizational structure and R&D management in internationalized public company

The EMBRAPA case

Tatiane Baseggio Crespi, Priscila Rezende da Costa and
Taísa Scariot Preusler
Universidade Nove de Julho, Sao Paulo, Brazil, and

Geciane Silveira Porto
*Universidade de Sao Paulo Faculdade de Economia Administração e
Contabilidade, Sao Paulo, Brazil*

Alignment of
organizational
structure

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Abstract

Purpose – The purpose of this paper is to analyze the organizational structure and R&D management alignment in an internationalized public company.

Design/methodology/approach – The authors performed a descriptive qualitative research using the single case method of EMBRAPA.

Findings – The results indicated that EMBRAPA organizational structure provides a structural framework for R&D management, promoting knowledge and infrastructure sharing. The internationalization, especially through LABEX, allows researchers to interact with research centers of excellence abroad. This makes strategic planning (Sistema de Inteligência Estratégico da EMBRAPA – Agropensa, portfolios and project arrangements) results in R&D projects, through macro programs, generating innovations for Brazilian agriculture.

Research limitations/implications – It should be noted that this study presents some limitations, among them, the fact that only one company is being analyzed.

Practical implications – Therefore, EMBRAPA's organizational structure provides a structural framework for R&D management, promoting knowledge sharing and infrastructure. This makes the strategic planning (Agropensa, portfolios and arrangements) to result in R&D projects, via macro programs, generating innovations for the Brazilian agriculture. On the contributions to the advancement of knowledge with regard to the professional management of public research institutes, it is worth synthesizing, therefore, the following practical evidence in the field and that they were key to the successful management of R&D activities in EMBRAPA.

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Originality/value – The choice of this company is due to its importance for the Brazilian agricultural development, to the innovations generated for the modernization of agriculture and due to it being a public, internationalized R&D company, and with a trajectory of four decades of existence.

Keywords Organizational structure, R&D management, Internationalization of R&D

Paper type Case study

1. Introduction

Agriculture is one of the economic sectors that has presented positive results, whose investments in research and innovation in Brazil have contributed significantly (Dossa & Segatto, 2010). Brazilian agriculture stands out in the national scenario and in the scope of international trade (Instituto Brasileiro de Geografia e Estatística, 2016; Silva, Braga, & Garcia, 2015). Between 1970 and 2016, Brazilian grain production increased by 555.6 per cent, and considering the cultivated area, the increase was of 148.81 per cent of the productivity (EMBRAPA, 2017a). These data reveal the relevance of this sector to the productive structure of Brazil, which aims to become one of the leaders in the sector. As the main contributors for the agricultural modernization, we emphasize the following:

- financial credit for the use of modern inputs;
- agricultural research carried out by EMBRAPA (Pereira, Martha, Santana & Alves, 2012; Rada & Buccola, 2012); and
- rural extension (Pereira et al., 2012).

Thus, support for science has been crucial for productivity gains. In this scenario, EMBRAPA stands out, acting nationally and internationally. It was created on April 26, 1973, it is public, private law (Coelho, 2009), linked to the Ministry of Agriculture, Livestock and Food Supply (MAPA) (Crestana, 2012). Its mission is “to promote sustainable development and competitiveness of agribusiness for the benefit of the Brazilian society” (EMBRAPA, 2015, p. 8). An important generator of agricultural innovations, the company has units strategically located in all regions of Brazil and has Virtual Laboratories Abroad (LABEX), distributed in several countries. In this way, it presents a very broad organizational structure, contemplating these research centers. In addition, to generate innovations, it has an R&D management system that covers the entire structure of the organization.

We should emphasize that in emerging countries, the performance of research companies, such as EMBRAPA, will depend, even more, on the ability to access external knowledge and to attach it to the capacities of its internal units that are dispersed geographically (Santos, 2006). This construction will require an intense improvement of the capacity to organize the knowledge that is dispersed in the decentralized units and in the external technological partners (Cyrino & Barcellos, 2006).

In this context, the research question arises:

RQ1. How does the alignment of organizational structure and R&D management in an internationalized public company take place?

To answer this question, this study proposes to analyze the alignment of the organizational structure and the R&D management of EMBRAPA, describing and analyzing its organizational structure and its R&D management systems.

The study of relationship established in a public and internationalized R&D company is relevant because it reveals aspects related to the mechanisms involved in a management

system that communicates with all levels of the organizational structure. Therefore, the study advances the theoretical knowledge about the organizational structure of an internationalized R&D company and the relationships of this organizational structure with the management and R&D system. Therefore, it enables the description of aspects related to R&D management, as well as governance aspects. It contributes by characterizing the structural framework and established relationships for R&D management, which relates to innovations generation. Above all, R&D project management systems and mechanisms for aligning demands and executing projects in an internationalized public research company.

For this purpose, we conduct a research of qualitative nature with a descriptive methodological approach and a single case study method, with EMBRAPA being the unit of analysis. The choice of this company is due to its importance for the Brazilian agricultural development to the innovations generated for the modernization of agriculture and because it is a public, internationalized R&D company, and with a trajectory of four decades of existence.

The results present the description of the organizational structure, organizational chart and the units dispersed strategically nationally and internationally. We describe the R&D management system and its structures, involving portfolios, arrangements, macro programs and R&D projects.

Through this study, we are able to advance knowledge about R&D management systems and the importance of alignment between management and organizational structure. Therefore, this article initially presents the theoretical reference in Section 2, and in the sequence, we present the methodology, analysis and discussion of the results in Sections 3, 4 and 5, respectively. Finally, we present the final considerations in Section 6.

2. Theoretical framework

The organizational structure is related to the institutional governance that according to [Ribeiro, Salles-Filho and Bin \(2015\)](#) involves aspects such as advisory councils, technical-scientific advice and business organization (direction, choice of management and organization chart), in addition to the normative aspects defined by the legal regime and the statute. In addition, organizations can be private or public with direct denomination integrating the structure of the Presidency of the Republic and ministries or state and municipal administration or indirect with legal personality and personal equity, linked to ministries or secretariats. Public organizations of the indirect administration include municipalities, foundations, public enterprises and mixed-economy companies. Thus, public companies are legal entities of private law and of public equity, being created by laws to serve public interests ([Coelho, 2009](#)).

Public R&D institutes are important for the development of countries ([Chen & Chen, 2016](#)), especially to areas neglected by private initiative ([Ramos & Cabral, 2015](#)). Given that organizational structure and its relations with the social-technological environment are complex, involving dynamic R&D management system ([Chen & Chen, 2016](#)). R&D has specific characteristics, which involve not only project management but also the technical management of R&D activities themselves ([Cassanelli, Fernandez-Sanchez, & Guiridlian, 2017](#)).

According to [Ribeiro et al. \(2015\)](#), we can divide the evolution of public research institutes at the global level into two phases. In the first phase (from 1980 until 1990), the structural evolution of these institutes was motivated by fiscal and financial crises, changes in the state's roles (including financial constraints), emergence of new fields of knowledge and technical-scientific transformations. Finally, the most representative performance of new actors, such as technological parks, incubators and startups that reorganized national

innovation systems (Laredo & Mustar, 2004; Salles-Filho, 2000; Salles-Filho & Bonacelli, 2010). The second phase (starting in the 2000s) was marked by a new wave of transformations (which is still underway). It notably highlighted the professional management of public research institutes, the new possibilities for insertion and sharing of knowledge in national innovation systems, institutional governance, the complete planning cycle, the maintenance and expansion of human resources, the capture and management of financial resources and the relationship with actors of the national innovation systems (Bin et al., 2013).

Thus, we are able to summarize decisive themes for the professional management of public research institutes (Ribeiro et al., 2015):

- Institutional governance: it involves the creation and institutionalization of governance models based on transparency; internal and external communication interfaces; internal and external representation, involving boards and committees; participatory management organization; generation of organizational innovations; professionalization of institutional communication; and accountability practices (Adler, Elmquist & Norrgren, 2009; Åström, Eriksson, & Arnold, 2008; Bin et al., 2013; Garcia & Salles-Filho, 2009; Hollanders & Soete, 2010; Jansen, 2007; Laredo & Mustar, 2004; Mattos & Abdal, 2010).
- Complete planning cycle: it addresses systematized planning practices for human, material and financial resources, encompassing their entire programming, monitoring and evaluation cycle (Arnold, Rush, Bessant, & Hobday, 1998; Åström et al., 2008; Bin et al., 2013; Hollanders & Soete, 2010; Salles-Filho & Bonacelli, 2010).
- Maintenance and expansion of human resources: it includes the traditional practices of contracting, training and development of specialized collaborators, as well as the development of more strategic practices of people management, including systems of continuous evaluation, reward systems and awards, agreement of cooperation and exchange of collaborators to expand the critical mass in particularized projects and use of the internationalization of the labor market, through the hiring of foreigners (Åström et al., 2008; Salles-Filho, 2000; Senker, 2000; Laredo & Mustar, 2004).
- Fundraising and management of financial resources: it involves institutionalized goals and practices for attracting financial resources from external sources as a way of complementing governmental resources (Arnold et al., 1998; Åström et al., 2008; Hollanders & Soete, 2010; Laredo & Mustar, 2004; Salles-Filho, 2000).
- Relationship with actors in national innovation systems: it includes the various initiatives for inserting institutes in national innovation systems, such as organization of events and fairs to disseminate research results; agreements and collaborative R&D agreements with companies, universities and other research institutes; transfer of technology to enterprises; Long-term research programs with universities and companies; R&D partnerships with universities and other research institutes for employee sharing and equipment exchange, among other initiatives (Åström et al., 2008; Bin et al., 2013; Dossa & Segatto, 2010; Hall, 2006; Hollanders & Soete, 2010; Mattos & Abdal, 2010; Senker, 2000; Vonortas, 2000).

Specifically, on the role of public research institutes in accelerating the business innovation process in Brazil, Oliveira and Telles (2011, p. 217) concluded that:

- The development of innovation in Brazil sought to bring together universities and businesses, but lacked models to stimulate the most costly and critical phases of the process, which are the pilot phases of proof of concept.
- The development programs should provide for a model of project articulation in which the main competencies are summoned to help solve major national technological problems.
- For this purpose, the institutes of technological research can function as articulators among the various actors of the innovation process in Brazil: government, business and universities and scientific and technological institutions.
- There is still the challenge of increasing the speed of the process, particularly regarding aspects of judging proposals and legal aspects of contraction when there are a large number of actors involved.

From the conclusions by [Oliveira and Telles \(2011\)](#), we note how relevant it is for public institutes of R&D in emerging countries, such as Brazil, to establish partnerships to articulate the various players in the innovation process, including business, university and government and scientific and technological institutions, with a view to combining knowledge and generating, in the end, open innovations. The combination of external and internal knowledge provides employees with the involvement in a knowledge network ([Tang, 2016](#)). [Ramos and Cabral \(2015\)](#) studied Embrapa research projects and found that heterogeneous teams increase the number of technologies generated by them. Partnerships, alliances and networks also contribute to increasing the generation of technologies. The authors emphasize that these networks involve intra-institutional interaction and external collaboration, that is, intra-organizational and inter-organizational networks. In addition, the geographical distribution facilitates the expansion of R&D networks ([Awate, Larsen & Mudambi, 2015](#)).

Thus, the process of combining knowledge has become increasingly evident, especially by the generation of open innovation ([Chesbrough, 2006](#)). In addition, the increase in technological knowledge grows and changes rapidly, which causes external knowledge to be increasingly sought, especially reliable and diversified knowledge ([Tang, 2016](#)). The author suggests the participation of R&D team members in events such as workshops, forums and cooperation actions with other institutes and universities as mechanisms for access to external knowledge. Therefore, there should be encouragement from managers to involve individuals in these mechanisms. For [Gascó \(2016\)](#), shared structures (living labs) establish enabling environment for knowledge exchange by enabling the integration of different actors, with emphasis on public research institutes, in the process of generating open innovation.

Another way of accessing knowledge is through internationalization, which has been the subject of recent studies ([Ribeiro, 2016](#)), and this became a movement both in companies in developed countries and in developing countries ([Leite & Moraes, 2014](#)). [Schreiber \(2015\)](#) emphasizes innovation can occur in the systematization of knowledge that contribute to the decision and the mechanisms of internationalization. Being that in the past decades R&D has been outstanding in the process of internationalization. The author also states that internationalization decisions may be linked to the search for competencies and resources; improvement of employees' skills and competences; and even, to outsource activities, via R&D service providers. Thus, we can analyze the internationalization decision through the following dimensions: economic theory ([Coase, 1937](#)), knowledge management, strategy and trust.

Pinto et al. (2017) emphasize the importance of government support for the internationalization of companies, especially Latin American. This support intends to leverage the economic power and capabilities of countries. In this context, R&D internationalization stands out, contributing to competitive differential (Schreiber, 2015).

The need to generate innovations requires interaction with public and private organizations, national and international, and it is important to foster strategic alliances that increase the use of resources (human and structure resource) and the use of opportunities, especially the acquisition of external knowledge. That is why the proposal "Alliance for Agricultural and Livestock Innovation in Brazil," together with the National Council of National Agricultural Research Systems (CONSEPA), with the support of MAPA and the Ministry of Science, Technology and Innovation (MCTI) (EMBRAPA, 2014).

The "Alliance for Agricultural and Livestock Innovation in Brazil" is, therefore, an indication that cooperation actions in R&D are increasingly necessary, as the insufficiency of the exclusive use of internal resources is complemented by interactions between organizations in the search for complementary resources (Sáez, Arribas, & García, 2002). Thus, R&D cooperation agreements can occur between two or more organizations to improve performance and competitiveness through resource sharing (Hitt, Dacin, Levitas, Arregle, & Borza, 2000; Ireland, Hitt, & Vaidyanath, 2002).

The highlight of R&D cooperation is notorious, as the economic, technological and innovative environment demands that technologies that are more complex to be developed more quickly. Therefore, many organizations prefer cooperation for technological development (Dossa & Segatto, 2010; Porto, 2004). Faced with this dynamism, Costa, Porto and Silva (2012, p. 3) define the term co-operability as the:

Intentional ability to dynamically develop cooperative projects, where partners create and/or share technological and innovative resources in local and/or global contexts, for sustainable generation of competitive innovation advantages that are distinctive and difficult to imitate.

Other factors that motivate cooperation actions in R&D are contribution to the minimization of transaction costs, facilitation of the relationship with uncertain environments and possibility of maintenance of the necessary resources on the control of the companies (Das & Teng, 2001). In addition, there is a greater propensity for large companies to cooperate with research centers, compared to small companies (Sáez et al., 2002).

We can also classify inter-institutional R&D cooperation as:

- informal links: motivated, often, by friendships, in the search for information and knowledge, expertise, equipment and financial support;
- of human resources: related to the improvement, training and recruitment and/or allocation of skilled labor, including internships and industrial projects; and
- formal: drawn up through formal contracts, through which cooperatives seek the exploitation of technical and scientific information, knowledge, expertise and equipment available in universities and companies (Dossa & Segatto, 2010).

It is worth mentioning that the planning, selection (Sáez et al., 2002) and monitoring are important for cooperating actions with the academia. This is a holistic view on establishing and managing R&D strategies, aiming to obtain technological and managerial effectiveness, in a process of continuous learning (Costa, Braga, & Galina, 2007).

Costa et al. (2007) emphasize the importance of proper administration of R&D cooperation involving company and university, considering them as an integrated system. This integration takes into account that scientific knowledge will be transformed into

technological innovations through the efficient management of financial flows, materials and information among those involved, whether from public or private institutions.

In summary, we can infer that the search for the development of technological innovations is going through an evolutionary process, from a closed to an open innovation system and to stimulate the establishment of strategic alliances. These alliances require efficient management, partner selection and contracts that include scope and governance structure (Shin, Kim & Park, 2016). In the study conducted by Shin et al. (2016) on innovative technological performance with companies in the area of biotechnology, classifying strategic alliances into three categories, according to the knowledge, resources and capacities, and the result indicated different transaction costs (Martins, Serra, Leite, Ferreira, & Li, 2010). In this study by Shin et al. (2016) vertical downstream alliances (pharmaceutical companies) were analyzed, with greater relation to commercial ends; vertical upstream alliances (universities, government research institutes), focused on generating knowledge; and horizontal alliances (biotechnology companies), which seek to integrate technologies. The positive effect of the moderator absorptive capacity was confirmed (Cohen & Levinthal, 1990) in upstream vertical alliances, demonstrating that it is highly important, especially in relation to tacit knowledge. The same has occurred with vertical alliances for innovative technological performance. Horizontal alliances, in turn, formed generally by potential competitors, demonstrated, after a certain threshold, greater risk of exposure of the body of skills and development of opportunistic behavior. Strategic alliances, therefore, require efficient management, partner selection and contracts that include scope, profits and governance structure.

Finally, it should be stressed that cooperation in R&D from strategic alliances can benefit economic performance, reducing risks and uncertainties. Another benefit is the elimination of duplication of research efforts and better appropriation of returns (Scott, 1996). With so many advantages, there is a growing need for experts and studies on the cooperation of management because it is a developing area, still lacks empirical research and trained managers. However, it is worth mentioning that, although essential, only effective management is not able to provide success in any technological development project (Porto, 2004), with the absorption of scientific and technological knowledge being necessary in the state of the art.

In view of the above, we present the following propositions:

- P1.* The organizational structure defined in specialized departments with geographic dispersion is capable of favoring the establishment of R&D networks and knowledge flow.
- P2.* The internationalization of public R&D Company broadens access to knowledge and sharing of R&D structure with centers of excellence, facilitating the flow of knowledge.

3. Methodology

The research is of qualitative nature, to understand the phenomenon in the context and of which it is inserted (Godoy, 1995a). The approach is descriptive methodological, following the positivist paradigm. We use the single case study method (Yin, 2001), whose choice is due to the relevance of this public and internationalized R&D organization for the advancement of Brazilian agricultural production. Therefore, the unit of analysis is the Brazilian Agricultural Research Corporation (EMBRAPA), linked to the Ministry of Agriculture, Livestock and Food Supply (MAPA), with the statutory objective of carrying

out R&D and making technological extension directed to the agricultural sector. It is the largest public company of Brazilian agricultural research, with more than 40 years' existence, offering technological innovations to rural producers enabling the advance of agricultural production.

Another point of distinction of EMBRAPA is due to its permanent staff of researchers (total of 2,444): 330 are masters; 1,829 are doctors; and 285 are post doctors, demonstrating the institutionalized practice in the company of retention of researchers with differentiated training.

The procedures for data collection were semi-structured interviews, observation and documentary analysis (Godoy, 1995b). The choice of interviewees was intentional. The instruments of data collection were reports, legislation, publications and information available on the website in the organization.

The research protocol involved semi-structured interviews with managers of the organization: with the advisor to the Research and Development Board and the R&D Chiefs of two decentralized units (totaling three interviews). People with extensive knowledge about the organizational structure and the R&D management system of the studied company. We recorded the interviews with permission and transcribed, totaling 22 pages. We collected secondary document data, with emphasis on the Embrapa's Master Plan and other strategic documents of the organization (totaling 319 pages), in addition to the organization's website.

The data analysis procedures we use are content analysis, focusing on ideas and not particularized words and triangulation (Marconi & Lakatos, 2007). The categories that led to the analysis and discussion of the results are organizational structure (Coelho, 2009; Ribeiro et al., 2015); R&D management (Cassanelli et al., 2017; Chen & Chen, 2016); and internationalization of R&D (Pinto et al., 2017; Ribeiro, 2016; Schreiber, 2015).

Content analysis also involved the use of IRAMUTEQ (*Interface de R pour les Analyses Multidimensionnelles de Textes et de Questionnaires*) software, which is free and allows different statistical analysis of the textual corpus (Camargo & Justo, 2013). In this study, we perform the similarity analysis demonstrating the proximity connections of the words.

The results are discussed in the literature. In a synthetic way, we present the search configuration in the mooring matrix (Mazzon, 1981). Demonstrating the study proposal and understanding of the research process (Telles, 2001) can be seen in Table I.

4. Analysis of results

In the following topics, we analyze the organizational structure, the management and internationalization of R&D in EMBRAPA.

4.1 Organizational structure

The organizational structure of EMBRAPA involves management, secretariats, departments, committees with emphasis on the various Units dispersed nationally and internationally (presented in the item internationalization). EMBRAPA has, in national territory, 17 Central Units (CUs) and 46 Decentralized Units (DUs) (Table II). The DUs are classified according to the area of activity: of products (14 DUs), eco-regional (17 DUs), basic themes (10 DUs) and services (5 DUs). Table II shows some DUs according to their categories.

The organizational structure of EMBRAPA involves units such as auditing, ombudsman, fiscal council and board of directors. Based on this, the top management consists of president and three executive officers (Administration and Finance, R&D and Technology Transfer). Top management and the Central Units (CU) are located at the

Specific objectives	Questions or points raised	Data collection procedures	Instruments for data collection of data	Source of evidence	Data analysis procedure
a) to describe the organizational structure;	Questions: What are the contributions of Virtual Labs Abroad (LABEX)?	Interviews	Semi-structured interview script	Embrapa's directors, managers	Triangulation and content analysis using IRAMUTEQ
	Document points: Organization chart, list and description of the units Structures of central and decentralized units	Documentary analysis Observation	Documents such as the master plan and websites Field notebook	Documents, site, publications Units visited	
b) to detail the R&D management systems of the studied company	Questions: How do R & D projects occur?	Interviews	Sem-istructured interview script	Embrapa's directors, managers	Triangulation and content analysis using IRAMUTEQ
	What are the characteristics of the arrangements, portfolios and macro programs? How do calls for projects occur? Elaboration, submission, selection? Document points: Agropensa detailing, arrangements, portfolios and macro programs	Documentary analysis	Documents such as the master plan and sites	Documents, site, publications	

Source: Research data

Table I. Study's tying matrix

headquarters in Brasilia, and the CUs are linked to the top management, either to the President or to the executive directors. They support the other DUs, which are also linked to top management and are classified as ecoregional, product and service units. In [Figure 1](#), we can visualize the EMBRAPA organization chart.

In general, the structure of senior management of the decentralized units resembles EMBRAPA's top management structure. Therefore, in leading these units, there is a general chief, who has three other deputy heads, with one being in administration, one in R&D and one in Technology Transfer (TT). This reflects the tripod: R&D, TT and the Administration that provides support for end-of-company activities to be performed. Therefore, R&D projects are supported by administrative sectors such as people management, budget and finance, vehicles and transportation, experimental fields, management of laboratories and patrimony and supplies, among others. Thus, although the project leader performs project management and technical activities ([Cassanelli et al., 2017](#)), these sectors are termed as research support.

In particular, the two DUs involved in the study present some specificities in their structures. Both are linked to General Management: Organizational Communication Center, Information Technology Center, Center for Institutional Development, Center or Committee for International Articulation, Quality Assurance Unit, External Advisory Council, Internal

Table II.
Decentralized units
of EMBRAPA

Decentralized units	
Product	Embrapa Cotton, Embrapa Dairy Cattle, Embrapa Soybean, Embrapa Rice and Beans, Embrapa Greenary, Embrapa Swine and Poultry, Embrapa Goats and Sheep, Embrapa Cassava and Fruits, Embrapa Wheat, Embrapa Forests, Embrapa Maize and Sorghum, Embrapa Grape and Wine, Embrapa Beef Cattle and Fishing and Embrapa Aquaculture
Ecoregional	Embrapa Acre, Embrapa Cerrados, Embrapa South Agricultural, Embrapa West Agricultural, Embrapa Temperate Agriculture, Embrapa Pantanal, Embrapa Agropastoral, Embrapa Cocais, Embrapa Rondônia, Embrapa Amapá, Embrapa Mid-North, Embrapa Roraima, Embrapa Western Amazon, Embrapa Pantanal, Embrapa Semiarid Agriculture, Embrapa Eastern Amazon, Embrapa Southern livestock farming and Embrapa Coastal Tablelands
Basic themes	Embrapa Agrobiology, Embrapa Agricultural Informatics, Embrapa Satellite Monitoring, Embrapa Agroenergy, Embrapa Agricultural Machinery, Embrapa Genetic Resources and Biotechnology, Embrapa Tropical Agroindustry, Embrapa Environment, Embrapa Food Agroindustry and Embrapa Soils
Services	Embrapa Coffee, Embrapa Information Technology, Embrapa Plant Quarantine, Embrapa Territorial Management and Embrapa Products and Market

Source: Research data

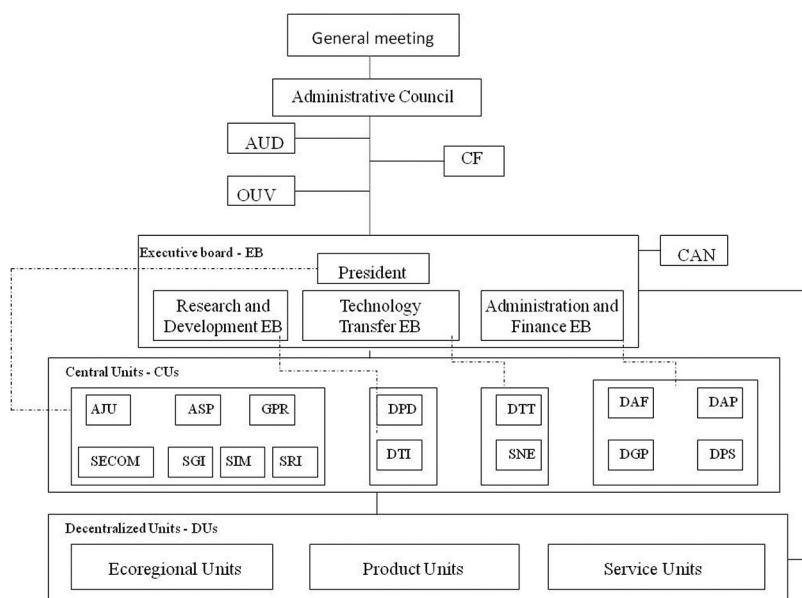
Technical Committee and Internal Biosafety Committee. One of the DUs, for working with animals, has an Ethics Committee for the Use of Animals linked to the Deputy Chief of R&D, the DUs have a Program Support Center and Thematic Groups or Research Groups. Connected to the Deputy Chief of Technology Transfer are the Implementation Sector of Technology Transfer Programming and the Technology Prospecting and Evaluation Sector. Some committees are linked to different management, such as the Local Publications Committee, which is related to R&D Management or the Head of TT and the Local Intellectual Property Committee, which is linked to the General Manager or the Deputy Head of TT. The Deputy Chief of Administration presents different sectors, as previously described.

4.2 R&D management at EMBRAPA

EMBRAPA has a broad R&D management system, covering CUs and DUs, in addition to LABEX. Increasing the sector's response capacity to opportunities and risks is the challenge of the EMBRAPA Strategic Intelligence System (Agropensa). This system operates in networks, and it seeks the production and diffusion of knowledge, to base the formulation of strategies of Research, Development and Innovation (R&D&I) and to anticipate tendencies and adequacy of priorities for the generation of innovations (EMBRAPA, 2014).

In the *Agropensa* domain, the EMBRAPA intelligence process has three main components, which interact in a network in a sequential process: trends observatory (capture and processing of database and information); analysis and studies (conducting analysis and studies then submit to EB for validation and use); and strategies (transformation of strategic information into action plans) (EMBRAPA, 2014).

The "trends observatory" performs the monitoring and prospecting of trends on agriculture in Brazil and abroad, in view of the profitable interaction and acquisition of knowledge between the EMBRAPA Units and LABEX (EMBRAPA, 2014). As a channel to receive this information, on the company's website, a request form and Agropensa's contact email is available. The information and signals received are sent to the Agropensa



Notes: Caption: Administrative Council: AUD: Internal Audit Advisory, CF: Fiscal Council and OUV: Ombudsman. EB: Executive Board, CAN: National Advisory Council, CUs: Central Units, DUs: Decentralized Units, Central Units linked to the Presidency: AJU: Legal Advice, asp: Parliamentary Advisory, GPR: President’s Office, SECOM: Secretary of Communication, SGI: Secretariat of Management and Institutional Development, SIM: Secretariat of Intelligence and Macro-strategy, and SRI: Secretariat of International Relations., Central Units linked to Research and Development EB: DPD: Department of Research and Development and DTI: Department of Information Technology., Central Units linked to the EB Transfer of Technology: DTT: Department of Technology Transfer and SNE: Department of Business., Central Units linked to EB Administration and Finance: DAF: Department of Financial Administration, DAP: Department of Administration of the Biological Station Park, DGP: Department of People Management and DPS: Department of Assets and Supplies

Source: EMBRAPA (2017b)

Figure 1.
Organization chart of
EMBRAPA

Management Committee (Comitê Gestor do Agropensa – CGA), which organizes the demands and indicates them to the CGE and the Executive Board (EB) (EMBRAPA, 2017c).

In the component “analysis and study”, we evaluate in detail the relevant themes, aiming to detect opportunities, challenges and barriers, which must be influenced by the process of technological development. From the knowledge obtained, there is the delineation of the “strategies” of action and decision making for the accomplishment of the objectives (EMBRAPA, 2014). The process involving these three components guides the R&D and EMBRAPA’s Technology Transfer (TT) agendas, as well as management plans.

The performance of EMBRAPA for the Brazilian agricultural development takes place, among other actions, through the innovations resulting from R&D projects and the

formation of strategic alliances, as expressed by the interviewee: “*The strategy of EMBRAPA projects is that it presupposes the formation of networks*”. The management system is, in such cases, organized so that the themes of R&D projects are aligned with the arrangements and portfolios, promoting technological advancement.

The management system, termed the EMBRAPA Management System (Comitê Gestor de Estratégia – CGE), adopted since 2002 (EMBRAPA, 2017d), enables a view of the whole, in an integrated and transparent way, as well as support the project management, to enable planning, execution, monitoring, evaluation and release of financial resources. The CGE has strategic, tacit and operational levels and is configured in six thematic macro programs, which organize and induce project portfolios to turn to technical-scientific quality and strategic merit. They are:

- major national challenges;
- competitiveness and sustainability;
- incremental technological development;
- technology transfer and business communication;
- institutional development; and
- support for the development of family farming and the sustainability of rural areas (EMBRAPA, 2017e).

To reduce redundancies and improve coordination (efforts and skills), EMBRAPA recently started to use two configurations to group the R&D projects: portfolios and arrangements. The portfolios carry out managerial support for the management of related projects, according to thematic view. The themes are strategically defined and have a corporate character (Table III) (EMBRAPA, 2017d). In other words, the portfolios agglutinate projects linked to a certain area. The portfolios follow the top-down strategy, that is, they intend to direct the results to be achieved in certain themes, which are strategic for the organization. Because it is a public research company, it has some demands that are fulfilled by the portfolios, as can be observed in the interviewee’s report:

As a public institution EMBRAPA needs to have directions whilst science and technology [. . .], linked to the demand of governments, demand for public policies, this generates portfolios.

Each portfolio has a management committee that elaborates the portfolio proposal (problems to be studied, relevance, impacts) which is referred to the Strategy Management Committee (SMG) for approval or not. Once it is, related projects are linked to the portfolio. New projects are also encouraged to compose the portfolio, in a complex system where partnerships are sought to collaborate with the work, forming a network of cooperation. As of 2017, EMBRAPA had 25 portfolios (EMBRAPA, 2017a).

The arrangements – groupings of projects that preferably involve different Units – challenge of specific themes and are classified as convergent, complementary and synergistic. There are 90 project arrangements, involving 300 external institutions (EMBRAPA, 2017a). Arrangements, in turn, have the bottom-up strategy, that is, they are integrated by projects that have complementarity and synergy, in addition to meeting the priorities themes for a set of EMBRAPA units.

In this R&D management structure, EMBRAPA projects undergo a process of calls, by which calls are made within each macro program via the EMBRAPA Programming Management System (IDEARE). This allows access to calls, launching project proposals and accessing information. In drafting the EMBRAPA projects, the action plans, their responsibilities and activities are determined, according to the calls of the macro programs.

Strategic macro-themes for EMBRAPA	Examples of portfolios of R&D projects	Examples of R&D project arrangements
New sciences: Biotechnology, Nanotechnology and Geotechnology	Genetic Engineering in Agribusiness; Genetics in Agribusiness; Strategic Management of Genetic Resources for Food, Agriculture and Bio-Industry (Regen)	Molecular and quantitative genetics for genetic gain and sustainable beef production (Maxibife); Nanotechnology in Agribusiness (Agronano)
Precision automation and agriculture and information and communication technologies	Automation; irrigated agriculture; Monitoring the dynamics of land use and land cover	Information and knowledge management for cattle breeding (Inovapec)
Zoo Phytosanitary security in the production chain	Plant and animal health	Sustainable management of fruit flies in Brazil (Moscafrut)
Natural resources and climate change	Coexistence with drought; biological control; climate changes; native forest resources	Development of production systems in the Matopiba region (Matopiba)
Production systems	Aquaculture; rational management of pesticides; Integration of Crop, Livestock and Forest (Integração Lavoura Pecuária Floresta - iLPF); pastures (Portpastos); ecologically based production systems; sugarcane	Recovery of degraded pastures in the Amazon (Repasto); Technologies for sustainability of the soybean production chain (Sustensoja)
Agro-industrial technology and green chemistry	Biological fixation of nitrogen; chemistry and biomass technology; nutrient supply for agriculture; oil palm	Agroecological innovation (Agroeco-NE)
Food safety, nutrition and health	Food, nutrition and health; safe food	Biological risks and strategies related to mycotoxins in maize (Micotoxmil)

Table III.
Macro-themes,
examples of
portfolios and
arrangements of
EMBRAPA

Source: EMBRAPA (2014, 2017d)

The evaluation of EMBRAPA's projects has two instances: one of them takes place internally, by the Internal Technical Committees (*Comitê Técnico Interno – CTI*); and another, within the macro programs for which they were submitted. The CTI carry out the project alignment evaluation with the mission of the Unit, analyzing the technical quality and relevance of the topic being addressed, as well as the contribution and structure for implementing. This opinion is delivered to the researcher, so that they may make any changes, if necessary, and return to the CTI for submission. The evaluation within the macro programs involves the receipt of proposals and verification of compliance with calls. Each macro program, in which the project is linked, has a manager, who becomes responsible for the coordination, from the evaluation of the technical merit of the selected project until its final evaluation. The evaluation of the technical merit is done initially by internal and external *ad hoc* consultants, whose position report are sent to the Technical Committee of Macro programs (*Comitê Técnico dos Macroprogramas – CTMPs*), with the proposal being approved or not. The Program Management Committee carries out the final evaluation, based on the strategic merit of the project. If it is approved with adjustments, the report returns to the researcher, who resumes the planning phase, and then there is a new

submission. This phase of information management (IDEARE) characterizes the dimension of assimilation.

The EMBRAPA project structuring system is composed of action plans, which are disaggregated into activities, with one of these plans usually being that of the project management; and others of a technical nature. The projects are implemented within a temporal logic segmented by four quarters, considered as sub-phases. In view of this, the number of sub-phases varies according to the duration of the projects. The release of funds also occurs every four months; the project leader does its programming in the IDEARE corporate system. An evaluation of the planned activities, made by its responsible, finalizes the sub-phases (four-month periods), being registered in the Project Portfolio Management System (*Sistema de Gestão de Carteira de Projetos – SISGP*). The SISGP provides prompt information on the timeline, evaluation of activities and records of any difficulties, such as completion, delivery on time, delays and cancellations. The implementation phase encompasses the analysis and combination of skills, knowledge management, intra and inter-organizational communication, the sharing of knowledge and information management system. The conclusion of the projects is with the final delivery of the results and the sending of reports in IDEARE corporate system.

There is also the post-project phase, which includes Technology Transfer actions and feedback from clients such as farmers, extension technicians and cooperatives. R&D and Technology Transfer (TT) Actions, generates knowledge and technology, classified in products, processes, information and services (EMBRAPA, 2014). We show some of these categories in Table IV.

It is worth mentioning that EMBRAPA is implementing the Technology Solutions Management system (*Sistema de Gestão das Soluções Tecnológicas – GESTEC*), a form of post-project evaluation, whereby the technologies generated by R&D projects will undergo a process of validation.

4.3 Internationalization of R&D

EMBRAPA's international activities are carried out through scientific cooperation and technical cooperation. Scientific cooperation takes place with international institutions with a scientific reputation for the exchange of knowledge and technologies. The instruments of cooperation are as follows:

Product categories	Process categories
Varieties and hybrids	Management of the agricultural system
Equipment	Food processing methodology
Animal cloning	Agro-ecological zoning
Vaccines	Integrated pest monitoring
Agricultural machinery	Precision modeling
<i>Information</i>	<i>Services</i>
Networks farming evaluation	Germ plasm exchange
Biological safety networks	Quarantine
Integrated pest monitoring	Consulting
Biosafety	Incubation of companies
Traceability and certification	Quality control
Genomics and functional biology	Trainings

Table IV.
EMBRAPA
knowledge and
technology examples

Source: EMBRAPA (2017a)

- Virtual Labs Abroad (LABEX) with infrastructure sharing with partner organizations, deployed in the USA, Europe, South Korea, China and Japan (ongoing implementation). It has a strategic role for Embrapa and for Brazil.
- Visiting Scientist at EMBRAPA is a corporate program that enables interaction with leading researchers at research centers of excellence abroad.
- Joint call program allows Embrapa and other institutes to submit proposals for joint research, sharing data, human resources and biological materials.
- Co-funded projects start from the interaction between scientists who use resources from national or international development agencies (EMBRAPA, 2017f).

Technical cooperation is an instrument of the Brazilian Government for Technology Transfer (TT) and capacities in developing countries, with support from the Ministry of Foreign Affairs. It occurs through structuring projects (larger projects), punctual projects (smaller projects) and agricultural innovation platforms (international initiative – Agricultural Innovation MKTPlace) (EMBRAPA, 2017g).

It is worth emphasizing that EMBRAPA is a company with experience in alliances. Its network of international collaboration, involves 97 bilateral agreements and 5 multilateral agreements, established in 44 countries and 84 institutions. In terms of technical cooperation, there are 56 projects with Africa, Asia, Latin America and the Caribbean (involving 40 countries); in addition to more than two thousand contracts with national and international partners (EMBRAPA, 2017a). These mechanisms promote a diversified portfolio of alliances (Moreira, 2016) and provide access to diversified external knowledge (Cohen & Levinthal, 1990).

Finally, we should add that information systems support R&D management in EMBRAPA, including national and international initiatives, with the main ones being synthesized in Table V.

5. Discussion of results

Since its foundation, EMBRAPA has provided continuous advances in the frontier of knowledge applied to agribusiness, solving relevant problems to the Brazilian model of agricultural development (Freitas Filho, Paez, & Goedert, 2002). This reinforces the importance of R&D Institutes for the development of countries as proposed by Chen and Chen (2016). Therefore, it is an internationalized public company, with an organizational structure and a defined and articulated R&D management system. The organizational structure shows the top management of the company (president and directors in the areas of administration, R&D and TT); CUs with specialized team in their areas of operation (e.g. legal advice, strategic business, people management, among others); DUs, strategically geographically distributed (national level) and having a similar management structure as headquarters (general management and deputy heads of administration, R&D and TT); LABEX strategically dispersed at an international level, are a source of knowledge obtained through the interaction of researchers and modern shared infrastructure. Therefore, the national and international geographical disposition allows the expansion of R&D networks, as proposed by Awate et al. (2015).

Thus, we can infer that *PI* is adherent, i.e. the organizational structure of EMBRAPA defined in specialized departments, with international geographical dispersion, is able to favor the establishment of networks of R&D and knowledge flow.

Information systems supporting R&D management	Function
EMBRAPA Program Management System (IDEARE)	DPD Manager Profile or CUs: develop and change calls; carry out and monitor the evaluation process; edit running projects; manage project reports; manage resource release for projects Leader profile or participant of projects or referees: check current calls and CGE calendar; prepare and edit new submissions, and consult projects in which they participate; to issue an ad hoc position or CTMPs member; elaborate and consult the budget distribution; consult information on arrangements and portfolios; complete, consult reports and report on project results; consult submission evaluation results; conduct textual research on running projects; view and get useful files DU or CU manager profile: to issue a report as CTI/CTS (new submissions); to issue a report as CLPI member; authorize participation of employees in projects; consult opinions of the evaluation process; see DU/CU submission list; validate reporting of project results; consult budget release of projects; consult employee participation in projects
Project Portfolio Management System (SISGP)	Employee or external partner profile: consult DU results; report on progress of activities; consult activities of action plans and projects under their responsibility; consult participation in projects, results and budgets Unit manager profile: check the amount of budget, projects and results of the DU; consult information per project Manager profile Department of Research and Development and Executive Board: consult project quantitative and quantitative results by EMBRAPA; consultation of EMBRAPA projects and the reports of the evaluation process
Technology Transfer Actions Management System (Sistema de Gestão de Ações de Transferência de Tecnologia - SISGATT)	Provides a cartography of EMBRAPA's performance in Brazil, by geo-referenced data
Technological Solutions Management System (GESTEC)	Includes all available EMBRAPA technologies
Competitive Cortex	Market monitoring and demand prospecting
Integrated Performance Management System (INTEGRO)	System that integrates all actions of projects and management actions and allows monitoring of the expected results
System of Planning, Monitoring and Evaluation of Individual Work Results (Sistema de Planejamento, Acompanhamento e Avaliação de Resultados de Trabalho individual-SAAD)	System used to evaluate employees and, consequently, for progression and promotion. It includes all activities planned for employees individually

Table V.
Main information systems to support R&D management at EMBRAPA

Source: Research data

This broad organizational structure is aligned with the R&D management system, through institutionalized management practices that allow interaction between different Units (Central and/or Decentralized and LABEX). The interaction allows sharing of knowledge, as occurs in R&D projects executed between different Units. In addition, researchers from a particular area, with specific knowledge of their areas of action, interact, share and advance knowledge, during the development of R&D projects together (other EMBRAPA Units and with external partners). In other words, the alignment of the organizational structure and management system allows the strategic dispersion, national and international, to promote the absorption of knowledge (Cohen & Levinthal, 1990) of different regions and execution of tests in different biomes.

EMBRAPA's R&D management system involves the management of projects and technical activities as proposed by Cassanelli et al. (2017). However, EMBRAPA's R&D management system involves superior R&D structures, which are the portfolios, arrangements and macro programs. These management structures allow the strategic alignment of R&D actions and, as a consequence, performance in networks of knowledge within each research macro-theme.

These knowledge networks involve not only members of different DUs but also external partners, especially through Virtual Labs Abroad (LABEX), as described by Ramos and Cabral (2015). This interaction increasingly converges with the generation of open innovation (Chesbrough, 2006; Ramos & Cabral, 2015; Shin et al., 2016). In this regard, international action is highlighted by the forms of interaction between researchers from different countries and shared use of modern structure to advance research. As a return, the Brazilian agricultural and technological advances, corroborating Pinto et al. (2017), as EMBRAPA is a public company, it has governmental support for its internationalization, which contributes to the leverage of Brazilian agricultural innovations.

Therefore, we can infer that $P2$ is adherent, i.e. the organizational structure of EMBRAPA, involving the Centralized Units and Decentralized Units (strategically geographically dispersed). Furthermore, its internationalization (providing interaction with international centers of excellence), facilitated the flow of knowledge and the generation of agricultural and livestock innovations. It corroborates conclusions by Oliveira and Telles (2011) that the institutes of technological research can and should function as articulators among the various actors of the innovation process in Brazil, including government, companies, universities and scientific and technological institutions. These conclusions also corroborate discussions by Ribeiro et al. (2015) that some practices are decisive for the professional management of public research institutes, including institutional governance, the full cycle of planning, maintenance and expansion of human resources, the capture and management of financial resources and the relationship with actors of the national innovation systems.

Finally, the aggregated data of the research evidenced the alignment of the organizational structure and the R&D management system of EMBRAPA, as observed in the similarity analysis (as commanded by IRAMUTEQ, Figure 2). This analysis graphically shows the shapes' proximity connections (words), we note that each color represents a grouping and its connections (branches). On the central group, represented in Figure 2, in the green color, highlighting "knowledge" obtained by the various interaction practices. The secondary groups are linked to knowledge and present varying colors. For example, from the alliance that is connected to knowledge, other words derive as intraorganizational, interorganizational, research and partner; the word "information", connected to "knowledge"

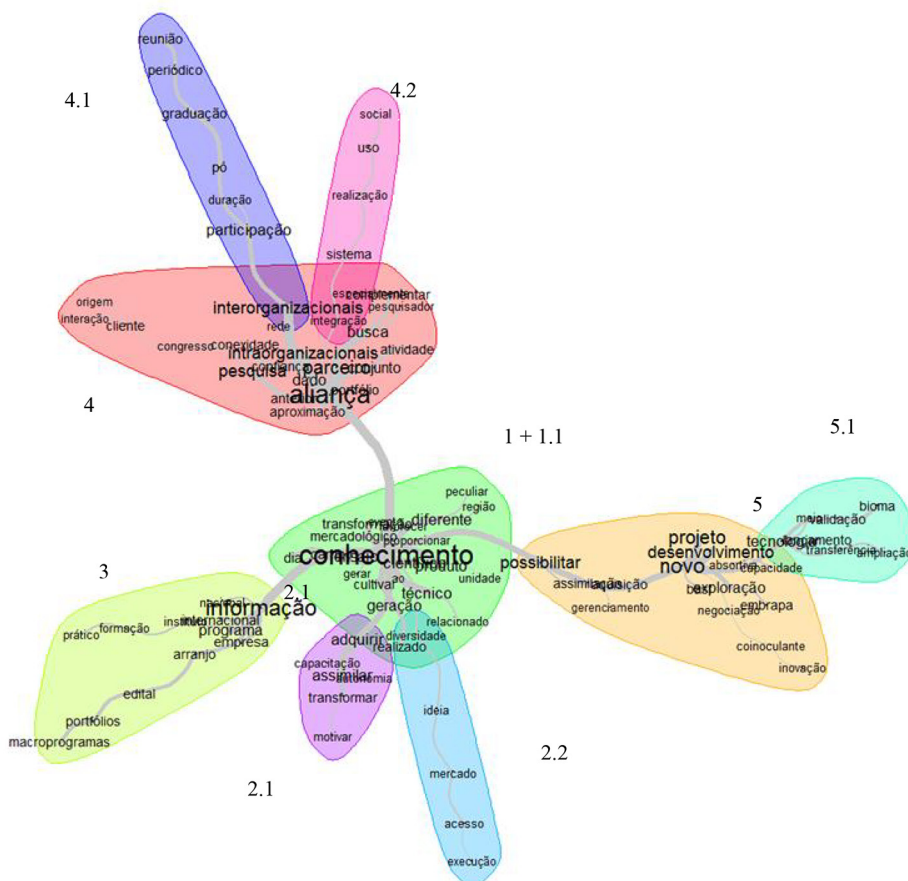


Figure 2. Similitude analysis obtained by the IRAMUTEQ software

Notes: The lexical data processed in IRAMUTEQ were in the Portuguese language; therefore, the software outputs were in the same language

Source: Research data

derives words such as arrangement, call for projects, program, company, portfolio and macro programs. The similarity analysis reveals, therefore, that the central word was:

- knowledge, expressed as (1.1) scientific, technical and marketing, whose ramifications revealed;
- their forms of absorption, including (2.1) acquire, assimilate and transform and (2.2) market access. In addition, these ramifications indicated the potential sources of knowledge, involving;
- portfolio, arrangement, macro programs and information of call for projects;
- intra-organizational and inter-organizational alliances; (4.1) participation in meetings, graduation and scientific journals; (4.2) social relations with researchers, and
- new projects; and (5.1) development and transfer of technology (Figure 2).

Thus, we are able to propose a representative model of the alignment between organizational structure and EMBRAPA R&D management system (Figure 3).

6. Final considerations

This in-depth study allows us to understand how the alignment of organizational structure and R&D management in an internationalized public company occurs. This is through the analysis of EMBRAPA, which is the unit of analysis of this study.

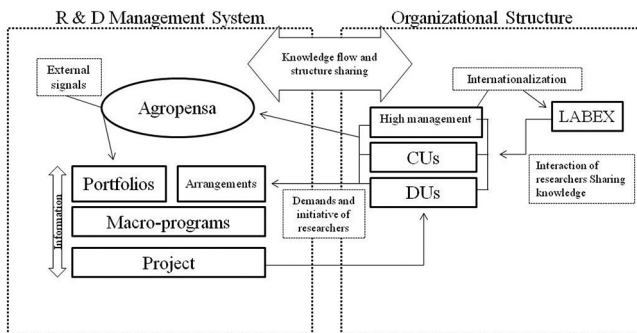
The organizational structure of EMBRAPA is broad, involving CUs and DUs that are geographically dispersed in a strategic way. The relationship established between these units is fundamental for the R&D management system to occur. This is because there is active interaction between the units, either for support or for joint implementation of R&D projects. In addition, internationalization, especially through LABEX, allows researchers to interact with research centers of excellence abroad.

The R&D management system involves macro structures such as portfolios, arrangements and macro programs and, at an operational level, R&D projects. The management system is aligned with the organizational structure for practices such as project development involving different actors, sharing of knowledge and structure. The results allow advancing the description of R&D management proposed by Cassanelli et al. (2017), including portfolio management, arrangements and macro programs.

Therefore, EMBRAPA’s organizational structure provides a structural framework for R&D management, promoting knowledge sharing and infrastructure. This makes the strategic planning (Agropensa, portfolios and arrangements) to result in R&D projects, via macro programs, generating innovations for the Brazilian agriculture.

On the contributions to the advancement of knowledge with regard to the professional management of public research institutes, it is worth synthesizing; therefore, the following practical evidence in the field and that they were key to the successful management of R&D activities in EMBRAPA:

- (1) Organizational structure: the organizational structure allows wide geographic dispersion at the national level through the DUs and access to important international research centers by LABEX. In addition, the governance model encourages the realization of R&D together among its various units. For administrative technical support, the CUs play a key role. All under the leadership of the president and three directorates, each focusing on a large area: Administration & Finance, Research & Development & Technology Transfer.



Source: Authors’ own elaboration

Figure 3. Descriptive model of the alignment between organizational structure and EMBRAPA’s R&D management system

- (2) R&D management: R&D management is based on portfolios and arrangements, so that R&D or TT projects are linked to the demands identified by external signs with top-down flow or by demands identified by the researchers themselves, with bottom-up flow. Therefore, it increases the capture of signals and identification of demands for the generation of innovations. The calls for projects, which occur via macro programs, where information is disclosed and projects are evaluated. Corporate systems such as SISGP and IDEARE are important tools for institutional communication of R&D activities, contemplating information of financial, technical, project execution and reporting of results.

R&D management also involves the planning, selection, training and improvement of human resources, in the search for a highly qualified research team. In addition, cooperation agreements and exchange of collaborators for centers of excellence seek to expand the critical mass in projects executed at the frontier of knowledge. These strategic practices of people management, include systems of continuous evaluation, reward systems (salary progression) and awards. To boost the actions of this research team, the incentive for transversal actions (projects involving specialists from different research centers), involving multidisciplinary team, with specialties related to the different geographical or technical peculiarities and infrastructure sharing. Therefore, providing not only acceleration in the advance of knowledge (through the complementarity of knowledge) but also acceleration in the generation of innovations by conducting R & D activities simultaneously in different locations/biomes/regions, shortening the period for generating innovation. In other words, organizational structure and aligned R&D management favor the generation of innovations.

- (3) Internationalization of R&D: The internationalization of R & D involves strategies such as:

- practices of international prospection of trends and sharing of structure in centers of R&D of excellence, via LABEX;
- R&D in cooperation agreements, making it possible to bring researchers closer together, through the exchange of researchers, use of structure and knowledge sharing; and
- incentive for technical improvement through congresses, symposia and international events, according to scientific relevance.

It should be noted that this study presents some limitations, among them, the fact we analyzed only one company. Therefore, future research can seek information about organizational structure and R&D management of other internationalized public companies. In addition, future studies can carry out comparative assessments with internationalized public research companies from different countries.

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Corresponding author

Tatiane Baseggio Crespi can be contacted at: tatianebaseggiocrespi@gmail.com

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