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Instituições públicas de pesquisa e investimento em P&D: uma avaliação institucional do caso Embrapii

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Resumo: O objetivo deste artigo é analisar a atuação da EMBRAPII dentro do Sistema Nacional de Inovação (SNI) brasileiro e entender se a instituição é capaz de colocar a economia na rota do *catch-up* tecnológico. Partindo de descrições de instituições similares ao redor do mundo, realizou-se um estudo de caso de uma Unidade Embrapii. O estudo de caso foi realizado via entrevistas com gerentes e gestores de projetos na unidade do Centro de Pesquisa e Desenvolvimento em Telecomunicações (CPQD). A principal contribuição deste estudo é trazer a ideia de que o conjunto de relações desenvolvidas via EMBRAPII representam um ganho para o SNI brasileiro, mas que não é suficiente para colocar o país na rota do *catch-up* tecnológico. A instituição fez crescer a janela de empresas que realizam projetos de Pesquisa e Desenvolvimento. Entretanto, tais projetos ainda apresentam um potencial inovativo tímido e não conseguem fazer com que o Brasil entre na rota do processo de *catching up* tecnológico.

Palavras-chave: Sistema Nacional de Inovação; Instituições; Embrapii; CPQD; Catch-up tecnológico

Código JEL: O31; O32

Área Temática: 4.3 Sistemas de inovação – nacional, regional, setorial, tecnológico

Public research institutions and investment in R&D: an institutional assessment of the Embrapii case

Abstract: The aim of this article is to analyze EMBRAPII's role within the Brazilian National Innovation System (NIS) and to understand whether the institution is capable of steering the economy towards the path of technological catch-up. Based on descriptions of similar institutions worldwide, a case study of an Embrapii Unit was conducted. The case study was conducted through interviews with managers and project coordinators at the Research and Development Center in Telecommunications (CPQD) unit. The main contribution of this study is to present the idea that the set of relationships developed through EMBRAPII represents a gain for the Brazilian NIS, but is not sufficient to put the country on the path of technological catch-up. The institution has expanded the pool of companies conducting Research and Development projects. However, these projects still exhibit modest innovative potential and fail to position Brazil on the path of the technological catch-up process.

Keywords: National Innovation System; Institutions; Embrapii; CPQD; Technological catch-up

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1. Introduction

The catching-up process depends on the complementarity relationship between the capabilities of the firms and the institutions of the National Innovation System (NIS). (Malerba and Lee, 2021) The NIS is composed of multiple agents (universities, laboratories, companies, among others). Therefore, the development of the NIS institutions is extremely important for the realization of the technological catchup.

This work focuses on one NIS's actor in particular: Public Research Institutes (PRIs), more specifically the Brazilian institution EMBRAPII (Brazilian Company for Research and Industrial Innovation) and its role on the technological catchup in Brazil.

Even though PRIs are not the first institution that comes to mind when discussing the actors of one NIS, they are still very important for the system's success. In this sense, Intarakumnerd (2011) compares one Taiwanese PRI (ITRI – Industrial Technology Research Institute) and one from Thailand (NSTDA – National Science and Technology Development Agency). The author argues that ITRI is an institution of a NIS that was able to put its economy (Taiwan) in the path of technological catch-up. The same cannot be said about NSTDA.

Suzigan (1996) and Suzigan and Furtado (2010) analyze the set of Brazilian institutions for industrial and innovation policies. They argue that, since the 80s, such a set has gradually weakened and, thus, constitutes one of the factors leading to poor outcomes for the country in both of these areas. This scenario began to change at the turn of the twenty-first century, with the increase in the magnitude of the funds for the development of the NIS in Brazil. The new scenario lasted until 2015, when there was a sharp cutback in these investments. (Tavares, 2024)

In this context of a substantial volume of funds, several industrialization plans were set in motion (PITCE³; PDP⁴; and PBM⁵) and new institutions were created. These included the Brazilian Company for Research and Industrial Innovation (Embrapii) – created in 2013. (Gonzalo et al., 2024) Originally, EMBRAPII was a PRI that aimed to expand the Brazilian NIS by bringing the basic research carried out at scientific and technological institutions closer to the demands of companies for innovation projects. In other words, it was an institution that aimed to assist applied research. (Gordon and Stallivieri, 2019) In recent years, the range of EMBRAPII's objectives has been expanded, and policymakers are also trying to use EMBRAPII as a tool for basic research. (Embrapii, 2023b)

When looking at PRIs, the literature usually focuses on the cases of countries that do not need to realize the catch-up process, like the Fraunhofer Institute (Germany) and the ITRI (Taiwan). This article tries to escape this scenario.

The aim of this article is to analyze EMBRAPII's role within the Brazilian NIS and to understand whether the institution is capable of steering the economy towards the path of technological catch-up. To that end, a case study of an Embrapii unit is conducted. The case study was based on semi-structured interviews with managers and project managers of the Telecommunications Research and Development Center (CPQD) – one of the most productive Embrapii units.

³ Industrial Policy, Technology of Foreign Trade: 2003 - 2007.

⁴ Production Development Policy: 2008 - 2010.

⁵ Plan "Brasil Maior": 2011 - 2014.

The main contribution of this study is to present the idea that the set of relationships developed through EMBRAPII represents a gain for the Brazilian NIS, but is not sufficient to put the country on the path of technological catch-up. Embrapii has managed to fight some of the defects of Brazilian NIS, which expanded the profile of the companies that carry out investments in research and development (R&D) projects. However, these R&D projects still show a somewhat timid innovative potential and are incapable of putting Brazil on the path to the technological catch-up process.

The study contains six sections. The second section discusses the literature concerning PRI's, the behavior of the Brazilian private sector and Embrapii. The methodological procedures appears in section three. Section four presents the case study results. Section five debates the results with the literature. The final section is reserved for the concluding remarks.

2. A literature review of PRI's, the behaviour of the brazilian private sector and EMBRAPII.

a. A brief review of literature on Public research institutes

The first thing that has to be done in this study is find a clear definition for PRI. From the beginning, it's clear that a PRI is an actor of one NIS. As Niosi et al., (1993) points out, a NIS is: "[...] the system of interacting private and public firms (either large or small), universities, and government agencies aiming at the production of science and technology within national borders" (Niosi et al., 1993, p. 212) So, by definition, a PRI is part of the NIS.

Going deeper into the discussion about the relationship between PRI's and NIS, OECD (2011) puts that, alongside universities, PRIs are the main governmental player in the NIS. Kang (2021) differentiates those two actors by highlighting that PRIs that PRIs: 1) use all their resources to research and 2) have more experience and less mobile researchers (when comparing to students).

The next step should be looking at what a PRI actually does. In that sense, Kang (2021) argues that a PRI can act as a "catch-up catalyst" (the author cites as exemples cases from East Asia where PRIs helped economies to catch-up – Korea, Taiwan, Thailand and Japan) or as "Innovation Seed Provider" (create new knowledge, new products or new applications). Ranjabar; Karimmian and Nesari (2024) point out four roles a PRI can have in a NIS: 1) reduce the risks that come with new technologies by disseminating standards; 2) facilitate technology transfers; 3) bridging universities, government and the private sector when searching for innovations; and 4) disseminate the latest results of researches in some fields "where applied programs have high scientific content." (Ranjabar; Karimmian and Nesari, 2024, p. 2)

With all that in mind, it can be said that the "standard model" of a PRI tends to work more with applied rather than basic research. In that sense, they are similar to another NIS actor: the Research Technological Organizations (RTOs). Giannopoulou; Barlatier and Pénin (2019) argue that RTOs should seek to increase business competitiveness; be short-term oriented; offer consultancy, services, diagnoses, or technological assistance; have mixed or private financing; be close to and remain in constant communication with businesses (important for applied research and for technology transfer). Their objective is to supplement the basic research carried out in universities. Hernández-Socha and Zuluaga-Jiménez (2024) suggest that RTO is an agent that creates and transfers knowledge between the players of an NIS. This is an important fact in the case of undeveloped NISs, as there is a greater chance of divergences occurring between those that create knowledge and those seeking it. Hecklau et al., (2020) affirm that RTOs are institutions external to universities that work with applied research projects at the intermediate stage of technological maturity. These institutions also strive to connect basic research with the demand of businesses for innovation projects. The literature tends to bring these two concepts closer together.

However, it has to be highlighted that when talking about the role of an PRI within an NIS, its design is a major factor. When analyzing five PRIs from industrialized countries (Fraunhofer –

Germany; ITRI – Taiwan; NIST – USA; AIST – Japan; CSIRO – Australia) Intarakumnerd and Goto (2018) highlight six variables (funding; researchers turnover; research agenda; performance evaluation; geography; and governance) to explain the different roles and objectives of each PRI. For instance, ITRI has: 1) a funding that relies on both the public and private sector; 2) high researcher turnover; 3) an applied research agenda; 4) a performance evaluating process based upon variables such as patents and similars; 5) units near partner firms; and 6) has direct relations with the ministry of economic affairs. NIST, on the other hand, has: 1) a funding based upon the public sector; 2) low researcher turnover; 3) an basic research agenda; 4) a performance evaluating process based upon variables such as publications and citations; 5) geography is not as big as a variable as it is for the other PRIs; and 6) direct relations with the Department of Commerce.

One more aspect worthy of note about PRI's is its potential for economic transformation. Besides the point that the development of a PRI work can lead to economic catch-up (Kang, 2021; Intarakumnerd (2011)), Ranjabar; Karimmian and Nesari (2024) also bring up the idea that PRIs can play a key role in the process of transition into a knowledge-based economy.

b. A brief review of literature on the behaviour of the Brazilian business sector

Suzigan and Villela (1997) and Suzigan (1996) state that between 1930 and 1970 the Brazilian economy managed to build a strong industrial base. But, with the changes in the scenario that happened in the 1980s, the industrial institutions and policies of the Brazilian economy were not able to continue the process of strengthening industry and innovation. The authors argue that, alongside with the direction of the macroeconomic debate at the time, the lack of answers provided by the set of institutions and policies for industrialization and innovation was the reason for the poor outcome of the country in those two areas.

Suzigan and Furtado (2010) take this argument further. The authors argue that during the 1980s and after, no industrial policy came to fruition in Brazil. This can be attributed to macroeconomic and institutional reasons. In the case of the latter, attention is drawn to six flaws that prevented an effective implementation of these types of policies in Brazil. These are: 1) their non-systemic approach; 2) their aging/adoption of out-of-date models; 3) their excessive complexity; 4) lack of qualification of their technical teams for undertaking current industrial policies; 5) engagement difficulties (whether with the government, or the private sector); and 6) coordination failures and weakened political leadership. (Suzigan; Furtado, 2010)

The scenario of weak industrial and innovation institutions only started to change in the late 1990s. De Negri (2023) analyzes Brazil's science and technology (S&T) institutions from the end of the 1990s to 2016. The author traces a timeline of the key policies and institutions created during this period. It is argued that the Brazilian S&T system gained traction during that period, but that it is still way behind those of the developed economies. Gonzalo et al., (2024) tread the same line and point out that during that period policies were created designed to develop industry and institutions with that same objective.

Resources for financing improvements to the Brazilian NIS were abundant exactly in the period analyzed in the timeline. Macroeconomic issues and a favorable external scenario made it possible to increase expenditure in an attempt to modernize the institutions of the national NIS. This scenario was turned on its head from 2015 onwards, leading to a reduction in investment in the Brazilian NIS. (Tavares, 2024)

Suzigan, Garcia and Feitosa (2020) take another step in that discussion. The authors analyze Brazilian industrial policy between 2003 and 2014. To do so, they divide this time into three periods: 1) 2003 – 2007; 2) 2008 – 2010; and 3) 2011 – 2014. In the first one, it is argued that the Brazilian industrial policy was able to open the door for a new set of behaviour rules that could lead to more investments in innovation by the private sector. However, in the latter two periods, this trend was reversed. Even though new institutions were created in an attempt to increase the efforts in innovation, the Brazilian private sector was now locked-in into a set of rules that did not incentivize these types of investments. On the contrary, the search for innovations was bound to the current or expected economic results, which makes it difficult to undertake investments whose aim is innovation.

c. A brief review of literature on EMBRAPII

EMBRAPII is a PRI within the Brazilian NIS that was created in 2013. As the last subsection showed, the the context of the Brazilian economy at that time was mark by two contrasting points: on one side there were abundant funds for modernizing the NIS institutions (Tavares, 2024), but on the other those institutions created or reformed were not able to create an environment that prioritize the behaviours related to investments in innovations (Suzigan, Garcia and Feitosa, 2020).

When EMBRAPII first was introduced, the institution had the objective of connecting basic research to the demands of businesses for innovation. In other words, it was basically connected to applied research. Its multiannual report (2014-2019) highlights:

EMBRAPII's institutional mission is to promote and incentivize partnerships between business and institutions of science and technology for undertaking projects in research, development and innovation based on recognizing the need to make better use of both public and private scientific and technological infrastructure installed at universities and several institutions over the last seven decades. (EMBRAPII, 2019, p. 14, authors translation)

And:

The essential purpose of the initiative was and is to channel the R&D-qualified work force existing in these institutions to strengthen and expand the opportunities of the industrial sector, creating the conditions need for bolstering RD&I activities in Brazil, bearing in mind the destructive contrast between the top scientific production at universities and research centers with the low degree of technological innovation of Brazilian companies. (EMBRAPII, 2019, p. 14, authors translation)

Gordon and Stallivieri (2019) argue that this process takes place at the so-called Embrapii Units (EU). These are Institutions of Science and Technology (IST) spread around Brazil that undergo an accreditation process, after which, if approved, they can receive funds from EMBRAPII to engage in projects in partnership with the contracting companies. In order to remain a part of EMBRAPII, units go through periodical technical and financial evaluations. To facilitate relations with the companies, the EUs are allocated according to their capabilities.

Until 2021, Embrapii was organized in one model that had two key points: the financing scheme and the focus of the contracted projects. The first one states that each unit's project portfolio is funded by the three agents participating in the relationship: the contracting companies have to fund at least one-third of the total; Embrapii itself must put up a maximum of one-third of the total; and the EU concerned must provide a maximum of one-third of the total (whereby the latter's resources can be financial or non-financial⁶). Also worthy of note is that the Embrapii portion is paid using non-refundable resources, the aim being to reduce the risk of the companies as there is no need to return these in the future. (Gordon;

⁶ Examples of non-financial resources are labor and infrastructure.

Stallivieri, 2019) The second point highlights the fact that the partnerships between the companies and Embrapii is the focus of the contracted projects. These involve applied research and are usually in the intermediate stage of technological maturity. Embrapii uses the Technology Readiness Level (TRL) scale that begins with TRL 1 (“Basic principles observed”) and goes to TRL 9 (“Full commercial application”). The joint projects with the institution focus on TRL 3 (“proof of concept”) and TRL 6 (“Prototype system”) or TRL 7 (“Demonstration system”). (Gordon; Stallivieri, 2019) and (EMBRAPII, 2023b)

As time went on, Embrapii felt the need to add other elements in order to engage in more disruptive innovation projects. With this idea, the Basic Funding Alliance (BFA) model was created. The BFA tries to stretch, in specific research areas, the technological maturity of Embrapii’s projects to lower TRL. BFA works with projects from TRL 2 (“applied research”) to TRL 4 (“laboratory demonstration”). Embrapii can finance up to 90 percent of the costs of BFA projects. (EMBRAPII, 2023b)

EMBRAPII (2023b) also brings up the partnerships Embrapii has with other institutions of the Brazilian NIS. The report highlights two of them: Embrapii – SEBRAE⁷ and Embrapii – BNDES⁸ partnerships. The first one aims to facilitate finance aspects of projects of small and medium-sized companies. The latter selects specific areas to develop projects with better conditions of financing⁹ and makes it possible for the EU to keep working on the project even when it reaches higher points in the TRL scale.

No matter the model of work or the partnership in place, Embrapii always tries to be agile and flexible in the process for granting funds to undertake the project. Negotiations involving issues arising with the projects take place directly between the companies contracting the projects and the EUs. Thus, an attempt is made to reduce bureaucracy and accelerate the process required for investment in R&D. (Gordon; Stallivieri, 2019)

3. Methodological Procedures

This article has a qualitative approach. It creates a case study based on primary and secondary data about one EU in specific and on semi-structured interviews/interviews by topics. According to Gil (2008), this type of interview is characterized by the interviewer allowing the interviewee to talk freely about the topic, but without diverting from it. The questions and interventions must take place in a way that keeps the interviewee on the issue in question.

The EU selected was the Research and Development Center in Telecommunications (CPQD) – one of the main EU – and the interviewees were managers and project managers of the institution.

4. Case study Results

a. A Brief review of the Embrapii Unit of CPQD

CPQD has a long history before EMBRAPII. The center was created in 1976 as an initiative of the Brazilian government for the purpose of developing national technology in the field of telecommunications and to master its emerging technologies. The institution was an important piece in

⁷ Brazilian Service of Support to the Micro and Small Companies.

⁸ National Bank of Economic and Social Development.

⁹ Such conditions vary according to the characteristics of the companies.

this strategy¹⁰, which was to engage in R&D of an applied nature and transfer technology to Brazilian-owned companies in the sector. (Augusto, 1999)

The operational guideline of the CPQD changed in the 1990s when its activities began to have less ambitious objectives of technological creation. Augusto (1999) argues: “[...] the CPQD’s activities were redirected towards technological capabilities in the services subsector, allocating it a less ambitious role in effort to develop industrial equipment.” (Augusto, 1999, p. 61). Crossetti (1995) points out that from the 1990s onwards, technology linked to technological solutions and services gained traction at the center, primarily those connected with software, microelectronics and optoelectronics.

Since CPQD joined EMBRAPII, it has become one of the main EU. It is one of the Units with the most projects (98) (EMBRAPII, 2023). Also, CPQD is the biggest unit in the southwest region of Brazil (the main region in terms of EU in the country). Finally, CPQD is one of the longest-lasting units (it has been registered as a EU since 2014, almost since the creation of EMBRAPII).

EMBRAPII (2023) brings a description of each project that the institution got involved in. Isolating the CPQD ones it is possible to create a dendrogram to have a better understanding of what the projects are about¹¹. In it, “data” appears as the leading term. Thereafter comes the idea of “Solutions”. “Solutions”, in turn, is divided into two branches: one that leads to “projects” and the other where a new bifurcation occurs. “Environment” appears in the highest branch of this new division. This continues into “digital” and “platform”. The lower division, in turn, presents “system”. The term “system” leads to a new division. One side introduces the ideas of “optics” and “technology” while the other shows “models”. “Models” is divided into “pictures” and “IoT¹²” and “devices”. “Devices” leads to “application”. From which the ideas of “management” and “monitoring” arise.

b. Interviews with the management and project managers of the Unit at the CPQD

Two managers and a project manager were interviewed. One point that appeared in all the interviews was that the Embrapii projects represent a large portion of the CPQD’s projects. In that sense, the unit undertakes projects only in the area of “advanced communications”. The Center has a total of 695 employees with the following level of education/training: 55 (technical education); 87 (on going college); 313 (complete college); 135 postgraduate; 78 (masters degree); 27 (PhDs).

When talking about the portfolio of projects, the main points that appear were: the relationship with the contracting companies, the financing schemes of the projects and the range of firms that seek CPQD for an Embrapii project. Regarding the first issue, it was said that the partnership with the private sector usually starts with companies reaching out to CPQD. But, sometimes the opposite can happen. Those projects tend to be concentrated in the TRL range of 3 to 6, but there are exceptions (usually for higher TRLs). Most of the projects are carried out in partnership with companies in the Southeastern (where CPQD is) or southern regions of Brazil. The companies are encouraged to participate in the projects as this facilitates the technology transfer process. However, any excessive company interference can adversely affect the project’s development. About the funding, the division is approximately: 50% came from contracting companies, 30% from Embrapii, and 20% CPQD. Also, the average project ticket is 1,5 million Reals. In relation to the latter topic, since CPQD became an EU the institution’s range of partner companies expanded (from multinationals to startups and micro businesses). The alleged reason for that change is the ease that the Embrapii model offers to companies and ICTs registered.

¹⁰ Others would be universities, industries, companies, among others. (Crossetti, 1995).

¹¹ The image of the dendrogram as well as a key to the chart are available in the exhibits.

¹² Internet of Things.

Aspects of the unit organization also appeared in the interviews. Evaluations from Embrapii consist of one financial and two technical. Geography is not a determining factor. However, the fact that the CPQD is close the centers that generate basic research (like UNICAMP¹³ and USP¹⁴) is seen as a positive point. Finally, the level of employer turnover is higher within the younger workers of CPQD.

5. Discussion of the results based on the literature

EMBRAPII fits the mold of PRI presented in section 2. In its first years, the institution was basically turned to applied research (very close to an RTO). From 2021 forward, EMBRAPII started to also focus on basic research. This change reveals that its institutional design is adaptable.

Institutional adaptability is the main positive aspect of EMBRAPII. Because of this characteristic, the institution faces two of the six institutional flaws pointed out by Suzigan and Feitosa (2010): the “aging/adoption of out-of-date models” and the “excessive complexity”. Design aspects such as: 1) The different types of work models; 2) the partnerships with other institutions (e.g SEBRAE and BNDES); 3) the division of the units into different research areas and 4) the possibility of direct negotiations between companies and EU tackles these two points are key to allow EMBRAPII to tackle those two institutional flaws. Also, the fact that the process to become and remain an EU involves an accreditation process and periodical evaluations (technical and financial) are arguments to say that the Embrapii model also tackles the “lack of qualifications of their technical teams” flaw.

The addressing of those three points is probably the reason for the expansion of the window of companies investing in R&D projects. As the interviews show, (and confirmed by the list of projects) the partner companies of Embrapii range from multinationals to startups and micro businesses. This creates a space for operating in a new way within the company's decision-making rule referring to investment in innovation – found in Suzigan, Garcia and Feitosa (2020) – which binds R&D expenditure to real or expected economic results.

Despite all this, CPQD (one of the main EU) still remains doing similar work that they did in the 1990s (activities center around “Technological Solutions”). In other words: the Center does not do much research that can lead to technological breakthroughs. This can be explain by two factors: 1) The number of masters and PhDs working at CPQD (the ones more capable of doing these kind of discover) is relatively small (15,1% of the total) (meaning that the EU is not ready for this type of work); and 2) The projects that are brought to the table by the firms are timid in terms of technology (meaning that the Brazilian private sector is not willing to make such investments). Those two points connect to the arguments made by Malerba and Lee (2021) – that the catch-up process is linked to a simultaneous evolution of firms and institutions capabilities – and Suzigan, Garcia and Feitosa (2020) – that the Brazilian institutional scenario does not change the averse behavior towards investment in innovation by the private sector.

This gives rise, therefore, to a curious situation. Embrapii has indeed improved the Brazilian NIS, but it has been unable to place the country on the road to technological catch-up. In order to accomplish this it will be necessary for the Brazilian State to continue to invest in the reform or creation of NIS institutions. These investments must have in mind the six flaws pointed out by Suzigan and Furtado (2010). If not, the country's innovation system could fall into the trap of having a big budget to invest on itself (Tavares, 2024), but not being able to create an institutional environment that induces

¹³ State University of Campinas.

¹⁴ State University of São Paulo.

firms to change their decision-making rule when thinking about investing in innovation projects (Suzigan, Garcia and Feitosa, 2020).

6. Final remarks

This article aimed to analyze EMBRAPII's role within the Brazilian NIS and to understand whether the institution is capable of steering the economy towards the path of technological catch-up. With the help of a case study of a EU (CPQD), it was argued that the institution is a step forward for the Brazilian NIS, but not sufficient to take the economy into the road of technological catch-up. The reason for these situation relies on two points: 1) Embrapiis design tackles three of the six institutional flaws pointed out by Suzigan and Furtado (2010): a) the “aging/adoption of out-of-date models”; b) the “excessive complexity”; and c) the “lack of qualifications of their technical teams”. Because of that the institution was able to expand the range of companies that invest in R&D projects. 2) However, as seen in the case study, these projects still seem timid in terms of technological breakthroughs.

To reach technological catch-up, there must be a simultaneous evolution of firms and institutions capabilities. (Malerba and Lee, 2021) The Embrapiis case shows that, when creating or reforming an NIS institution, one must always keep in mind the vices of the NIS that need to be tackled. Some of the Brazilian institution flaws were taken care of, but these were not sufficient to make the private partners of EMBRAPII change enough their behaviour related to investment in innovation projects. The necessity of constantly thinking about the institutional flaws of the NIS is the main message this article has to offer for policymakers.

The present article has four main limitations. The first one is the lack of historical distance to make a more detailed judgment. EMBRAPII was created in 2013 and the BFA was born only in 2021. The second point is the difficulty to generalise the findings of the case study. Although CPQD is one of the most important EU, it is still only one of them. The third one is the difficulty to measure technological intensity within the projects. The qualitative approach chosen for this article makes it harder to analyze it. The data lacks density and the authors lack technical knowledge. Finally the idea of “technological catch-up” can be viewed as too broad, with the need of picking certain areas.

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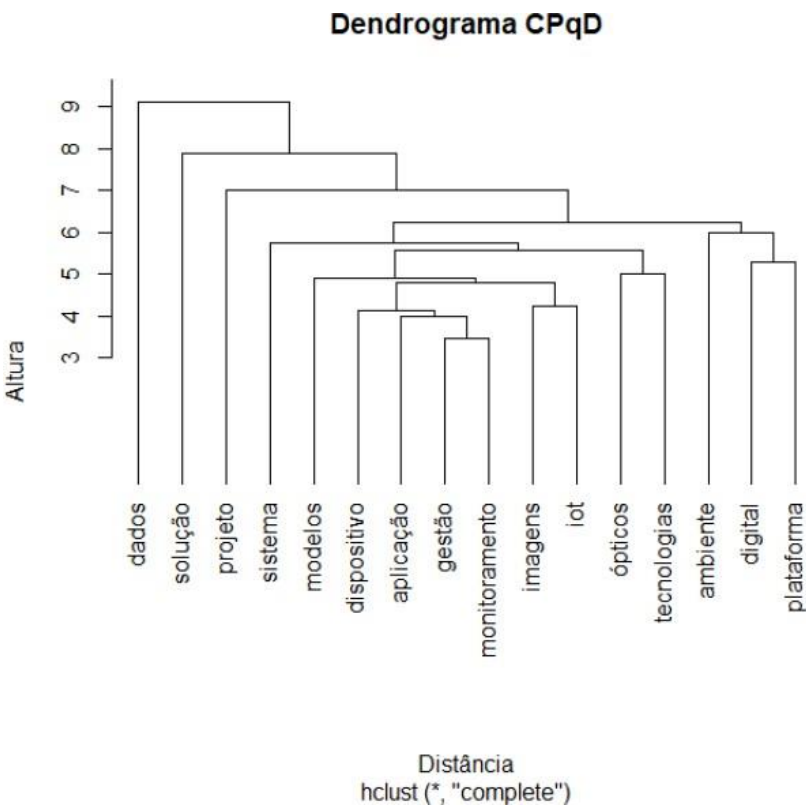
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EXHIBITS

Figure 1. CPQD project descriptions dendrogram



Source: Embrapii (2023); prepared by the author

Key to the chart

Altura	Height
dados	data
solução	solution
projeto	project
sistema	system
modelos	models
dispositivo	device
aplicação	application
gestão	management
monitoramento	monitoring
imagens	images
iot	iot
ópticos	optics
tecnologias	technologies
ambiente	ambiance
digital	digital
plataforma	platform
distância	distance
Dendrograma CPqD	CPqD Dendrogram
distância	distance

