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Learning from productive development agencies in Brazil: Policies for technological innovation

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Abstract[*]

This paper presents and comparatively analyzes three case studies of productive development agencies (PDAs) in Brazil: Embrapa, Finep, and ABC Foundation. Following a discussion of the main hypotheses and the methodology employed, the paper describes each case, the related counterfactual and an analysis of each PDA's capabilities. A subsequent section presents a comparative analysis of the PDAs, studying: i) the use of hybrid forms to assemble complementary capabilities: short-run effects on technological policy; ii) the effect of strategic alliances on building capabilities and dynamic effects; and iii) how industry structure and innovation should affect PDAs' strategies. Finally, the paper presents conclusions, summarizing results, methodological shortcomings and policy implications.

JEL classifications: D73, L3, L38
Keywords: Productive development policy, Productive development agencies, Industrial policy

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1. Introduction

This paper aims to identify capabilities in Productive Development Agencies (PDAs) and how they map into the delivery of public policy. The study presents three case studies of PDAs in Brazil: Embrapa, Finep, and ABC Foundation. All three PDAs have as a common general purpose delivering policies for technological innovation and technological catching up. This similarity allows for a controlled comparison of this type of policy, which arguably requires different capabilities. With this comparative analysis design, this study intends to provide additional insights from the comparison among the three case studies.

An important hypothesis that guides our study is that technological innovation (and arguably for other public policies) requires complementary capabilities that usually are not found within the same organization. Moreover, capabilities in general cannot be purchased; they must be built within the organization. For that reason, in order to deliver a successful technological public policy, the PDA must have the capability (a meta-capability) to articulate different organizations to combine complementary capabilities.

As a counterfactual, in all three cases we explore the time variance within each case in a "before-and-after" comparison. The idea is to compare capabilities before and after the episode and how they might affect the success of the delivered policy. This strategy is certainly not a robust counterfactual, since the episode itself, may have happened because of some PDA features already in place before the episode (i.e., they are not exogenous shocks). The before-and-after study can be interpreted as a "pseudo-counterfactual," but we submit that they are still informative to identify the main question about agencies' capabilities and their effect of public policy. In some of the cases, it was possible to establish a brief comparison with an alternative productive development agency that has not gone through a similar episode or that differs from the reference case in a key-variable.

The main instrument for collecting information in case studies was semi-structured interviews with PDAs' representatives and beneficiaries, in which the researchers gave leeway to the interviewees to add subjects that were not anticipated at the beginning of the study. Formal documents from the PDAs and quantitative assessment of their implementation experience, as well as papers and articles on the related subject, were used in this study.

For semi-structured interviews we relied on a short questionnaire that contains the main elements to be investigated, which offers a guide to the interviewer. The draft of this questionnaire is presented in Appendix 1.

The remaining of this paper is organized as follows: Section 2 raises the main hypotheses that orient the case study analysis and provides further details on the methodology. Section 3 encompasses a description of each case, the related counterfactual and an analysis of the capabilities in each PDA. Section 4 presents a comparative analysis of the PDAs, studying: i) the use of hybrid forms to assemble complementary capabilities, ii) the effect of strategic alliances on building capabilities, and iii) how industry structure and innovation should affect PDAs' strategies. Finally, Section 5 presents our conclusions, with a summary of the results, the methodological shortcomings and policy implications.

2. Hypotheses and Methodology

2.1. Theoretical Background and Hypothesis

Public policies are carried out by organizations. In order to explain how effectively public policies are implemented it is necessary to fully understand these organizations, their capabilities and how they use their resources to achieve their goals. The organizations investigated in this research are productive development agencies (PDAs). These agencies basically differ in their key capabilities, which may be bundled into three complementary types: technical, organizational and political (Cornick, 2013). Depending on their available capabilities and on their ability to acquire and built new capabilities, agencies can be more or less effective in their aim of promoting productive development.

Within the same organization, it may be necessary to combine different capabilities to implement public policies. Technical capabilities are required for more accurate decisions and, as is usual in PDAs, for innovation. However they may not be enough to implement a policy that also requires legislative innovation or concerted actions of government bodies, which involves political capabilities. Moreover, the articulation of complementary capabilities may require the collaboration of different agencies, since it is unlikely that a single agency will encompass all capabilities required for implementing productive policies.

In the case of public policies oriented toward promoting changes in production structures, organizations may be part of the state, as direct executive branches or state-owned enterprises, or

an arrangement built within the production arena to organize collective interests and to promote collective policies. Often these two alternative forms of organizations for implementing public policies (state-owned or collective arrangements) interact in a complementary way to accomplish their aim of promoting development.

This research explores variations in those forms of organizations in order to investigate the pros and cons of each type of organizational arrangement. We claim that productive development policies benefit from coordination among different agencies or between agencies and other organizations, such as private companies, in particular if the capabilities necessary to deliver the public policy are non-tradable and complements. In addition, we also claim that some PDAs' organizational features that are permanent or less flexible (e.g., public autarchy versus state company) affect the development of specific types of capabilities. To support these hypotheses, this research anchors the analysis on both the development literature (Cornick, 2013; Schneider, 2013; Pritchett, Woolcock and Andrews, 2010) and on the institutional economics literature, in particularly on the branch of organization studies (Barney, 1991; Araujo, DuBois and Gadde, 2003; Barney and Clark, 2007; Teece, Pisano and Shuen, 1997). These two perspectives contribute to a better understanding of how organizations built capabilities and how those capabilities are used to implement productive public policies.

The conventional view of capabilities hinges on the proposition that organizations develop competitive advantages when they organize their internal resources, notably non-tradable expertise, in order to foster the productivity of the other resources available to them. An important conclusion of this literature is that an organization cannot easily acquire capabilities from other organizations or in the market; they rather have to build capabilities by means of their own experience and effort, deliberate or not. As a consequence, capabilities are specific to and rooted in each organization.[1]

Nevertheless, joint ventures provide evidence that capabilities may also be created by combining complementary resources that belong to the different organizations that participate in the joint venture. If those resources were easily tradable, it would not be necessary for two organizations to engage in a joint venture and assemble a new set of resources. In the more

[11] See Makadok (2001).

general and interesting case, though, resources are not well defined goods that can be acquired in the market.

These co-specialized investments create quasi-rents, since alternative uses for the same resources would generate a lower return. As a consequence, transaction costs emerge both due to the potential for hold-up (Grossman and Hart, 1986) and to ex post maladaptations (Williamson, 1985, 1996). These costs potentially inhibit specific investments in the partnership, in particular the combination of complementary resources.

An alternative for dealing with transaction hazards created by co-specialized resources is to gather all these assets within the same hierarchy (or equivalently all required capabilities in the same PDA). Mergers combine companies with complementary non-tradable resources, and they can be used as an alternative to long-term partnerships. This combination of complementary resources is typically a source of efficiency gains in antitrust merger analysis, which usually attributes causality between the merger and these gains (FTC-DoJ, 2010). On the other hand, as assets are often inseparable, a merger cannot perfectly select desirable (i.e., complementary) assets and neglect non-desirable assets, a situation that favors the design of partnerships instead of mergers. For instance, a pharmaceutical company willing to launch a new drug could merge with another company that had a more comprehensive and efficient sales team. In doing so, the first company would also acquire several assets with low or no value for its operations. In short, different governance structures may be used to assemble complementary assets (for instance, capabilities), but they are subject to unavoidable trade-offs. That is what Williamson (1985) terms "impossibility of selective intervention," a concept that will be used in the case study analysis of PDAs.

A similar idea appears in Cornick (2013), who reckons that organizational features are key to the success of public and private partnerships. In particular, the long-term stability of the partnership requires mechanisms that support cooperation among different and autonomous organizations. The governance structure needs to prevent the capture of the public agency or bureaucracy, by means of transparency and accountability; and, simultaneously, it needs to align incentives to public and private parties by means of pecuniary compensation and other forms of reward.

This initial discussion gives support to some hypotheses that guide the case studies included in this paper. First, when complementary capabilities relevant for delivering public

policy are located in different organizations, governance structures that induce cooperation among those organizations may be more effective than efforts to replicate those capabilities within the same PDA. Since it is costly and time consuming to build capabilities, partnerships may result in more effective public policy (Araujo, DuBois and Gadde, 2003). This need for cooperation is particularly important in technological policies, because technological capabilities are typically non-tradable and may be located in different organizations. The capability to combine existing capabilities in different organizations—i.e., a meta-capability—is also known as indirect capability (Loasby, 1998). Together with the costs of building capabilities internally, those capabilities determine the optimal scope of organizations and the set of capabilities they encompass.

Second, in the case of technological policies, the distribution of capabilities among organizations—in particular between PDAs and firms—varies according to the technological features of production. For instance, there are capabilities for innovation in industrial sectors that are located within firms and cannot be easily replicated by PDAs. In those sectors, the knowledge required for innovation is predominantly tacit and requires experience to accumulate (Dosi, 1988). As a consequence, if one wants to trigger innovation in such an industry it is necessary to access those capabilities embedded in firms. Hence, PDAs that aim to promote technological innovation must be effective in stimulating the use of capabilities that are firm-specific. Often these capabilities can be combined with the scientific knowledge and laboratory infrastructure that is present in universities and research institutes. In those cases, technological policy needs to articulate capabilities within firms with those of research institutes.

In contrast, by and large technological capabilities in agriculture are not specific to farms. Instead they can be found and accumulated in PDAs or in research institutes. This difference between industry and agriculture has implications for the organization of technological PDAs, which can vertically integrate technological capabilities in agriculture, but they need to develop the capability to articulate firms' technological resources in order to trigger innovation.

Third, capabilities accumulate with deliberate effort and experience. Organizational choices in each PDA are relevant to determine what types of capabilities tend to accumulate more. For instance, the set of incentives and control mechanisms that generate internal labor markets (e.g., low turnover, promotion within the organization, among others, as noted by Doeringer and Piore, 1969) are conducive to the accumulation of human capital specific to the

organization but provide lower incentives for the accumulation of generic human capital. As pointed out by Williamson (1996), organizational choices imply intrinsic trade-offs that cannot be avoided by means of selective intervention. As a consequence, organizational choices, such as the choice between autarchies versus non-governmental agencies, are important determinants of the current and future PDA capabilities.

The above discussion provides the support for the following propositions.

- Prop 1: *When complementary capabilities relevant for delivering public policy are located in different organizations, partnerships that combine them result in more effective public policy*.
- Prop 2: *The need for partnerships to trigger innovation is lower in sectors where the relevant technological resources can be accumulated in PDAs (e.g., agriculture), and it is higher in sectors where relevant technological resources are embedded in firms (e.g., capital goods and other industrial sectors).*
- Prop 3: *PDAs are subject, like any form of organization, to intrinsic trade-offs that helps to explain the accumulation of specific types of capabilities, which the transaction costs literature calls 'impossibility of selective intervention'.*

2.2. Methodology

The method for analyzing the three selected PDAs is the case study (Yin, 2003; Baker and Gil, 2012). For a comprehensive contextualization and the detailed appraisal of PDAs' capabilities, data were collected from several different sources, both of quantitative and qualitative types. The main instrument for collecting information was semi-structured interviews with PDAs' representatives and beneficiaries, in which the researchers give leeway to the interviewer to add subjects that were not anticipated in the beginning of the research. Formal documents from the PDAs, quantitative data, and information collected in the PDA website were also useful when available.

The first step of the research is mainly descriptive, with the purpose of understanding what the relevant capabilities in each PDA are and how they are used in the implementation of public policies. The second step addresses the problem of causal relationship between capabilities and the degree of success in policy implementation, as well as that of

complementarity among different capabilities, in particular the technological, organizational and political types. The causal relation is addressed by a qualitative approach, which is usual in in-depth case studies. This approach has high internal validity but low external validity, since the selection of cases is not random and representative of the whole population of PDAs (Yin, 2003).

In order to assess the causal effect it is necessary to build a counterfactual, which is not directly observable. As an alternative, the analysis relies on two types of comparison in what may be called a pseudo-counterfactual. In all case studies an episode is selected, a specific historical event in each PDA that is relevant for understanding the building of capabilities and the mapping between capabilities and the efficacy of the intended public policy. The first type is a before-and-after comparison, which focuses on changes in capabilities and on public policy efficacy that can be attributed to the selected episode. The second type is a comparison between a pair of cases that differ in one particular variable of interest, such as organizational choices or industry features. The purpose of this second type of comparison is to address the issues raised in the beginning of this section, such as the relationships among organizations' choices (e.g., internal labor markets within PDAs and the accumulation of specific types of capabilities).

This study selected three productive development agencies (PDAs) for in-depth case studies. In order to ensure a meaningful comparison among the case studies, all three PDAs deal with the same basic problem: technological innovation and technological catching up. Moreover, the cases studies explore variations in organizational form (state-owned enterprises versus collectively funded private organizations) and in their respective strategies of fostering technological innovation (e.g., internalization of technological innovation versus financing technological activities within firms).

The three selected PDAs are the following: Embrapa, Finep, and ABC Foundation.

1. Embrapa (Brazilian Agricultural Research Company) is a state-owned enterprise, founded in 1973 and linked to the Ministry of Agriculture, Livestock and Food Supply. It is a technological innovation firm that develops and disseminates new technologies, as well as supports the development of public policies for the technological development of Brazilian agriculture. Embrapa is one of the few successful cases in developing countries of public research institutes for agriculture, performing R&D investment of public interest both in the segments in which the private sector has no interest in

investing (in markets with low profitability) and those in which private sector participation is not significant.

2. FINEP (Financiadora de Estudos e Projetos) is the Brazilian Innovation Agency, publicly owned and linked to the Ministry of Science and Technology, based in Rio de Janeiro. It aims to promote technological innovation in industrial sectors by means of financial support to specific projects undertaken by firms, universities and research institutes.
3. ABC Foundation is a nonprofit organization, maintained by contributions from producers and partnerships in research with private companies, that offers soil testing services, food science knowledge and geographic information systems. The ABC Foundation was first established in 1954, originally under the name of Cooperativa Central de Laticínios do Paraná Ltda, in a region called the Campos Gerais in Southern Brazil's Paraná State. Located in a region characterized by poor soils and low fertility, ABC Foundation was created with the purpose of providing technical assistance to farmers (agriculture and livestock).

2.3. Measuring Capabilities

Capabilities are not directly measurable and cannot be expressed in numbers. The numbers of PhD researchers in a PDA or of patents are only poor proxies for technological capability, and it is even more difficult is to find proxies for organizational or political capabilities. Although measuring capabilities is a challenging task, it is useful to evaluate different PDAs in terms of their capabilities, which allows for comparison among them and the mapping between capabilities and the efficacy of public policy. This study attempts to measure capabilities by means of qualitative assessment by a group of researchers, following methods such as Rapid Appraisal (Beebe, 1995) that translate evaluation by experts into a multidimensional scale.

Based on the table of capabilities from the Appendix of the IDB's Call for Research Proposals (reproduced in item 5) of Appendix 1, the authors of this paper evaluated the technical, organizational and political capabilities of each PDA. The capabilities evaluated were divided into the following dimensions, according to the table in item 5 of Appendix 1:

1. Technical:
    - Scientific/technocratic expertise
    - Bureaucratic efficiency
2. Organizational
    - Public-public coordination
    - Public-private coordination
    - Experimentation and learning
3. Political
    - Credibility
    - Creation of support groups
    - Protection against capture (public and private)

The abovementioned capabilities dimensions were classified by the group of researchers on to the following scale: i) very strong, ii) strong, iii) medium, iv) weak, v) very weak. To transform those qualitative evaluations into quantitative terms and radar/spider graphs, those evaluations were then converted into numerical rates from 0 (very weak) to 4 (very strong).

In order to ensure that the evaluation would take into account all relevant information, each item was subject to a full discussion by the whole group of researchers, which followed the presentation of the researcher directly responsible for the study. The grades were then submitted to some of the interviewees—representatives of each PDA—in order to validate the first assessment. A table with a summary of the data obtained as explained above is presented in Appendix 4.

3. Cases

3.1. EMBRAPA

3.1.1 What is the Agency and Which is the Selected Episode?

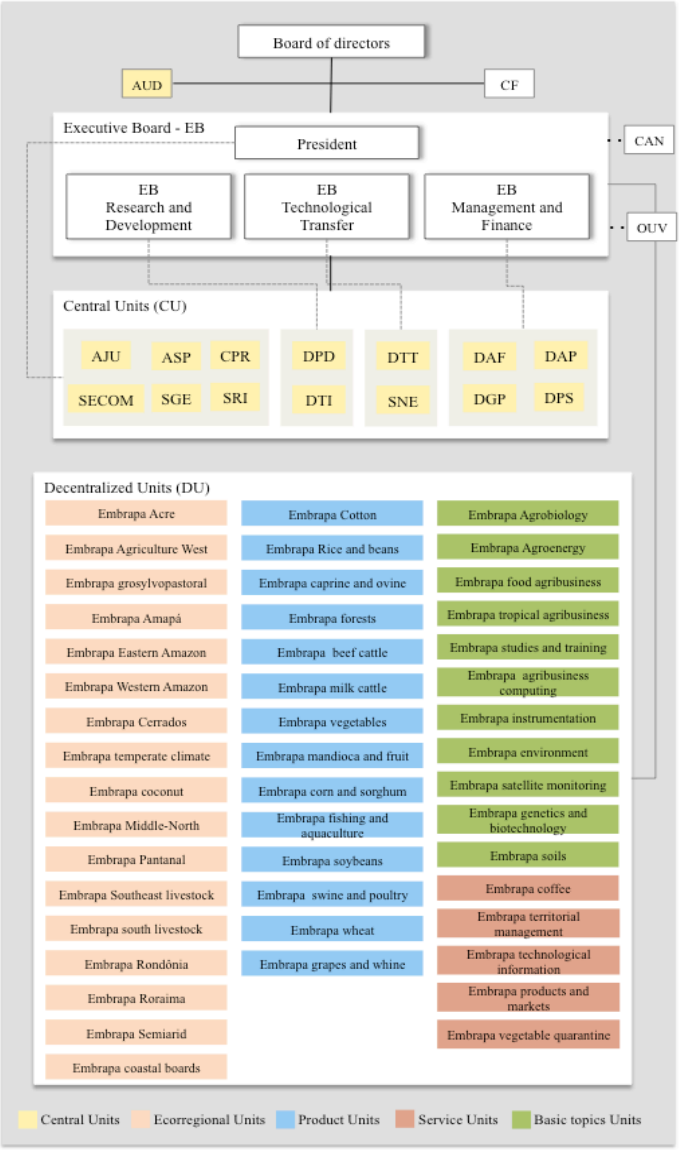
Embrapa (Empresa Brasileira de Pesquisa Agropecuária, Brazilian Agricultural Research Company) is a state-owned enterprise, founded on April 26, 1973 and linked to the Ministry of Agriculture, Livestock and Food Supply (Ministério da Agricultura, Pecuária e Abastecimento, MAPA) (Embrapa, 2014).

Embrapa is a technological innovation firm that develops and disseminates new technologies, as well as supports the development of public policies for the technological progress of Brazilian agriculture. To this end, Embrapa performs R&D investment of public interest, both in the segments in which the private sector has no interest in investing (in markets with low profitability) and those where private sector participation is not significant. In the 1980s Embrapa consolidated its position as an innovation source for Brazilian agriculture and developed cultivars adapted to the climate and soil conditions of the Brazilian savanna (cerrado).

Aiming at being "[…] a world leader in the creation of knowledge, technology and innovation for sustainable production of food, fiber and bioenergy" (Embrapa, 2014), Embrapa is one of the few successful cases in developing countries of public research institutes for agriculture and, hence, is an interesting starting point for this capabilities analysis (Correa and Schmidt, 2014).

In order to accomplish its purposes, Embrapa has been segmented into two main fields, R&D and Technological Transfer, with other financial, administrative and supporting units. To this end, the company has been divided into 15 central units located in Brasilia, 47 decentralized units located in the various regions of Brazil, four virtual laboratories abroad and three international offices (Embrapa, 2014), as depicted in Figure 1 below.

Figure 1. Embrapa's Organization



Source: Embrapa (2014).

It is worth noting that, despite the administrative segmentation of the R&D and Technological Transfer units, there is a strong connection between those divisions. The interaction between both divisions and between those divisions and outside institutions is depicted in Figure 2.

Figure 2. Embrapa's Interactions

Source: Embrapa (2014).

Embrapa's complete organizational structure employs 9,790 people, including 2,444 researchers, 2,503 analysts, 1,780 technicians and 3,063 assistants. One of Embrapa's most notable features is its technical capability: 18 percent of its researchers have a master's degree, 74 percent have a doctoral degree and 7 percent have a post-doctoral degree.

The company's budget relies on funds made available by the Federal Government as well as its own program of research funding called Macroprogram, which supports investments in basic and applied research. In 2014, Embrapa's yearly budget was over R$ 2.6 billion (Embrapa, 2014).

As a state-owned enterprise, Embrapa has legal personality under private law, but its equity capital belongs 100 percent to the Brazilian Government. Consequently, Embrapa must operate under certain rules similar to those of any governmental entity, including those for hiring personnel and contracting with third parties (private or public). In a nutshell, Embrapa's operational structure is a little less rigid and bureaucratic than a public body but much more rigid

and bureaucratic than a private company since its legal regime more closely resembles that of a public sector organization.

For instance, Embrapa's employees have rights equivalent to those of civil servants, meaning that they are hired through public tenders and have more job stability than employees working in the private sector. Moreover, the company is subject to Law No. 8.666/93, which sets out the general rules for procurement procedures and government contracts. Hence, Embrapa is subject to rigid, bureaucratic and time-consuming contracting rules.

If on the one hand this inflexibility could be considered an appealing characteristic for employees in the 1980s and 1990s (especially researchers willing to focus on their academic and scientific career), on the other hand it is a disadvantage in Embrapa's relations with private companies and in achieving the necessary flexibility to adjust contracts to the innovation process.

The selected episode (as detailed below) is the signing of licensing contracts between Embrapa and Monsanto in 1997 (and subsequent years) for the implementation of a partnership to develop and produce transgenic soybean resistant to the herbicide Roundup. The case was selected as an illustration of Embrapa's engagement in strategic alliances with private firms (previously considered solely as competitors) in the seeds industry in order to meet its innovation objectives more efficiently and effectively. The selection of this episode has been motivated by both theoretical and practical reasons. First and foremost, we have found that the above-cited episode has in fact constituted an important milestone for Embrapa.

3.1.2 Historical Context and Description of the Episode

Embrapa was created to address the Brazilian Government's growing concern with the country's lack of technical capabilities in agriculture. In a context of rapid population and income growth of population and income—as well as trade openness—it became clear that, without investments in agricultural research, Brazil could not reduce the gap between demand growth and the supply of food and fiber.

The development of agricultural research in Brazil was late and atypical, with centralization of the activity only in the 1970s. Some Latin American countries, for example, had already adopted an institutional framework—National Systems for Agricultural Research (INIAS)—that were designed to coordinate and manage limited resources (Ruttan, 1983): INTA

(Argentina, 1957), INIAP (Ecuador, 959), CONIA-FONIAP (Venezuela, 1959-1961), INIA (Mexico, 1960), SIPA (Peru, 1963), ICA (Colombia, 1963) and INIA (Chile, 1964).

In 1992, the National Agricultural Research System (Sistema Nacional de Pesquisa Agropecuária, SNPA) was created. It is made up of Embrapa and its Research Units and Services, State Organizations for Agricultural Research (Organizações Estaduais de Pesquisa Agropecuária, Oepas) and federal or state-level universities and research institutes, as well as other public and private organizations directly or indirectly related to agricultural research. The main goal of the SNPA is to achieve coherence between guidelines and strategies for agricultural research and wider development policies.

As for its human resources policy, as a state-owned enterprise Embrapa is required to select its employees by means of public tenders, i.e., by hiring the best-performing candidates in a public examination, subject to Law No. 8.666 (EMBRAPA, 2014). This works as follows: first, all qualifying candidates undertake the exam; next, the *n*-best performing candidates are considered approved; finally, within the next two years, those "approved" applicants may or may not be effectively offered a job, based on the needs of the organization.

This hiring process is both time and resource-consuming and therefore requires the company to plan ahead and select a given number of employees in each tender, even if it is not obliged to effectively hire all the best-performing applicants. Moreover, legal constraints generally do not allow public companies to fire employees as easily as private firms do. As a result, public employees benefit much more from so-called "job stability" than their private peers. This job stability creates incentives for a long-term career within Embrapa, and hence to investment in assets whose return depends on job tenure.

These long-term incentives, along with a stable and predictable yearly budget, allow Embrapa to select the best professionals available on the job market and enable it to make major investments in their training. For example, Embrapa provides for employees' doctoral studies both in Brazil and abroad whenever they are needed and possible. As a result, 81 percent of Embrapa's 2,444 researchers (as mentioned above) have at least a doctoral degree, demonstrating Embrapa's strong technical capabilities.

Furthermore, the abovementioned hiring process also influences and shapes employees' approach to work as well as their technical capabilities. For instance, because of long-term career incentives and encouragement to enhance qualifications, researchers are both allowed and

encouraged to experiment and develop new technologies and processes. Embrapa's employees thus have an incentive to produce technological and scientific knowledge for Brazilian agricultural producers (Mendes and Buainain, 2013).

Other aspects of Embrapa's status as a state-owned enterprise likewise shape its organizational capabilities, though not always to its benefit. For example, because Embrapa's relationship with outside suppliers and other private companies is constrained by the rules of Law No. 8.666, it is not as fast and flexible in contracting as private organizations are. While this regulatory structure enhances the company's control and provides consistency in most contracts, it also slows down relationships with the other parties and might even prevent Embrapa from establishing desirable partnerships.

To provide individual incentives for researchers, R&D scientists are evaluated in terms of their number of publications in scientific journals, similarly to incentive systems found in universities. While on the one hand these could be regarded as desired organizational capabilities, on the other, such a performance indicator slows down the dissemination of newly developed technologies, both because scientific publication is time consuming and because it requires the contents to be original, i.e., not disseminated elsewhere first. This constitutes a major difference relative to private firms, which are pushed towards faster response rates by competitive pressures, even if this means less freedom to experiment and learn.

Last but not least, Embrapa's political capabilities should be noted. The company has an excellent reputation, shaped by its solid technical capabilities, i.e., Embrapa is able to build credible commitments because its partners believe it to be technically capable of delivering what has been agreed upon. At the same time, Embrapa is relatively independent from the government, which seems not to influence or shape new public policies developed within Embrapa, even though assisting policymakers is one its statutory objectives. Nevertheless, Embrapa's overall credibility, as well as its good relationship with and positive reputation among farmers, gives local government little leeway to change its yearly budget. This relatively secure situation holds important implications for Embrapa's technical capabilities, as the company enjoys the necessary independence to focus on urgent matters rather than current officeholders' agendas.

These characteristics of Embrapa explain why, until the 1980s, there was very little interaction between the institutions that created new agricultural technologies and the users of

those technologies. In the 1980s, a debate arose between technology institutions and the market, such that public research institutions and universities were criticized for being distant from market demands and producers' needs, even though they had a considerable amount of knowledge available (Mendes and Buainain, 2013). Embrapa subsequently increased its interaction with private companies, using multiple mechanisms for management, transfer and marketing of the science and technology generated in partnerships with them.

Although Embrapa had already entered into partnerships with the private sector in the late 1980s and early 1990s (especially with foundations and producers' associations such as Fundação MT and Unimilho), an exogenous event also played an important role in pushing Embrapa into this type of partnership: the enactment of the Cultivar Protection Law (Lei de Proteção aos Cultivares, LPC) on April 25, 1997. In fact, the editing and promulgation of the LPC resulted from Brazil's participation in the TRIPs Agreement (Agreement on Trade-Related Aspects of Intellectual Property Rights) in 1994, which required a general review of Brazilian laws on intellectual property rights. In 1996, Embrapa approved its intellectual property management policy through Resolution (Deliberação) No. 22/96 (Embrapa, 2014), which was crucial in transferring the technology generated by Embrapa to the market (i.e., companies and producers).[2]

The LPC attracted private companies to invest in Brazil, since it allowed them to appropriate their investments in technology innovation in the seed industry (especially international companies who developed technologies abroad and had avoided bringing them to Brazil due to the lack of legal protection). It is also important to note that Brazil is the world's second-largest producer of soybeans, in the world, with a 1997 harvest of 26,391,448 tons (FAOSTAT, 2014). A sector of this size almost inevitably held significant potential for transgenic soybeans.

While multinational companies had knowledge in transgenic germoplasm, they did not have access to the germoplasm adapted to Brazilian soil and climate conditions (or they would have to spend a considerable amount of time and money to study and develop adequate varieties,

[2] Another important regulation that directly affected the local cultivars and seeds local market was the Brazilian Biosecurity Law, from March 24th, 2005 (Law No. 11.105), which allowed the cultivation of genetically modified (GMO) seeds.

while this research had already been undertaken locally). Embrapa, on the other hand, had great knowledge of locally adapted varieties.

Hence, the LPC made it possible for public institutions such as Embrapa to articulate (in some cases) and solidify (in others) partnerships with private companies. The major benefits for public institutions were their proximity to the market, facilitating proper implementation of the technologies by producers, and the use of private funds to finance at least part of their research. The seed industry benefited from those partnerships by obtaining cultivars adapted to the different areas of Brazil.

The logic behind the partnerships between Embrapa and the private sector is straightforward. The latter supports a breeding program, the cultivars developed are protected according to the LPC and registered in the developer's obtainer's name, and seed production generates revenue to the parties involved through licensing and royalty payments (Da Cunha, 2011).

As a result of the LPC, a great number of new cultivars were developed. According to De Carli (2005), from January 1998 to February 2005, 627 cultivars of 27 species were registered as protected before the MAPA, in the name of 81 different institutions (private and public). It is in this scenario that the partnership between Monsanto and Embrapa emerged: a hybrid form that enabled the rapid adaptation of Monsanto's seeds to the Brazilian market, contributing to greater efficiency of technological development of Brazilian agricultural policy.

Replicating transgenic soybean seeds can be relatively easily. Therefore, in the absence of legal protection of the intellectual property involved, the significant investment required to develop this technology is hardly recovered by the company, since agents can purchase the product only once and then copy the technology.

Considering the above-mentioned information, it is reasonable to assume that investments in this type of technology are only made in countries with protection systems for the technology itself, such as patents. This is the case for the United States and Europe, which have had laws protecting plant genetic technology since the 1950s, 1960s and 1970s. Consequently, large multinational companies such as Monsanto became world leaders in this area (Moura and Marin, 2013).

Roundup is the most used herbicide in the world and Monsanto, besides being the developer of the herbicide, is also the sole holder of the transgenic soybean germoplasm resistant

to Roundup. In 1997, the genetically modified soybeans whose technology was held by Monsanto represented 66 percent of the soybean seeds in the world (Moura and Marin, 2013).

On the other hand, Embrapa was the leader in soybean cultivars adapted to Brazilian soil and climate conditions: in 1997, 70 percent of the soybeans cultivated in Brazil were derived from Embrapa's cultivars (Moura and Marin, 2013). However, Embrapa did not have access to the transgenic soybeans held by Monsanto.

The first agreement signed between Monsanto and Embrapa is dated April 22, 1997 and had the purpose of developing transgenic Roundup-resistant soybeans adapted to Brazilian climate and soil conditions. The new cultivars, developed based on Embrapa's germoplasm bank allied with Monsanto's technology of resistance to glyphosate, were registered with the Brazilian National Cultivar Registry (Registro Nacional de Cultivares, RNC) in Embrapa's name under LPC protection. However, since the Roundup Ready technology is patented by Monsanto (under the Intellectual Property Law protection), licensees have to sign one agreement with each institution and pay royalties to both of them. When combined, the capabilities of the two companies allowed for the rapid and cheaper development of transgenic soybean specifically designed for Brazil (Moura and Marin, 2013). In other words, these products complied with Embrapa's objective of technologically developing Brazilian agriculture in an efficient and effective way.

In this partnership, technical capabilities are obviously crucial to developing novel solutions. Next, strong organizational capabilities are required in order to rapidly respond to farmers' needs and to support all the operations involved with technological development. Finally, political capabilities are to some extent needed to support the credibility of Embrapa's commitments and the development of its technical skills.

The different groups of capabilities are closely interrelated, not only in that no successful policy can be developed without considering all three of them, but also because they seem to mutually influence each other (i.e., they are not totally independent/orthogonal). For example, some of the same factors that enhance Embrapa's technical capabilities also make its organizational capabilities relatively weaker.

To gather in-house all the necessary capabilities required for efficient and effective innovation, Embrapa would have to eschew some features enhancing one type of capability rather than others. Undertaking a partnership with Monsanto meant that the latter could provide

complementary technical capabilities in a field different than Embrapa's area of expertise, as well as organizational capabilities that allowed for the rapid responses and decision-making required given the high speed at which innovation took place.

3.1.3 Episode Outcomes

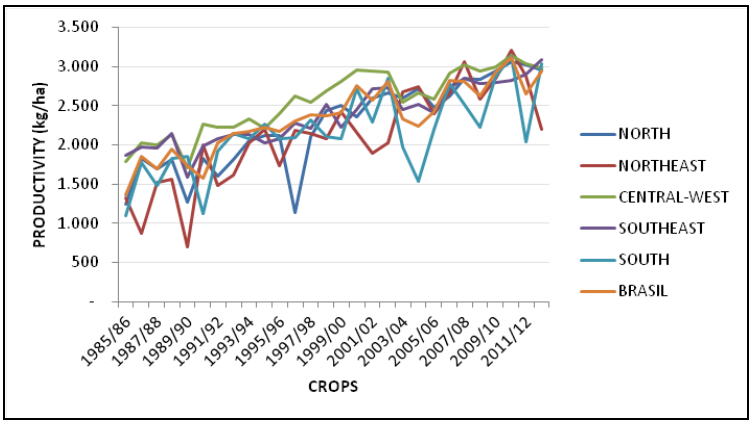
The episode we have selected illustrates the growth in the number of partnerships between Embrapa and private firms that have been established since the publication of the LPC.

Embrapa's partnerships with the private sector made it possible to improve the capacity of developing new cultivars throughout Brazil, expediting the process of spreading and applying the technology and providing the necessary financial support.

The main type of development in Embrapa's cultivars was the incorporation of resistance to certain soybean diseases in both "new" and "old" cultivars, reducing the producer's need for pesticides (Embrapa, 2004), which complemented the partnership between Monsanto and Embrapa. From 2001 to 2004, the number of seeds licensing agreements rose from 651 to 1,500, and the production of licensed seeds went from 225 thousand tons to 463 thousand tons (Embrapa, 2004).

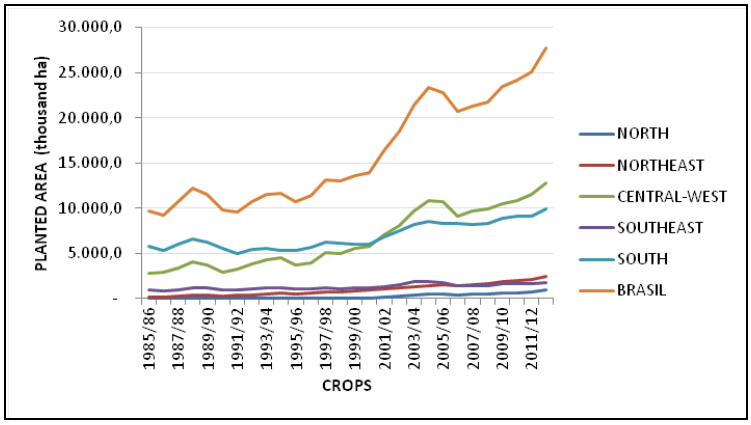
Soybean productivity has been increasing at a regular pace, although one cannot attribute this result to Embrapa's partnerships with the private sector (Figure 3). The planted area has been increasing (Figure 4), and so has the production of soybeans (Figure 5), especially in the Central-West Region of Brazil. These results are probably driven by foreign demand, but they also reveal the ability of Brazilian production to respond to this demand shock, which is consistent with the hypothesis that Embrapa's new policy was successful. Moreover, the vast majority of soybean varieties cultivated in Brazil directly or indirectly originate from Embrapa's partnership with Monsanto.

Figure 3. Soybeans Productivity



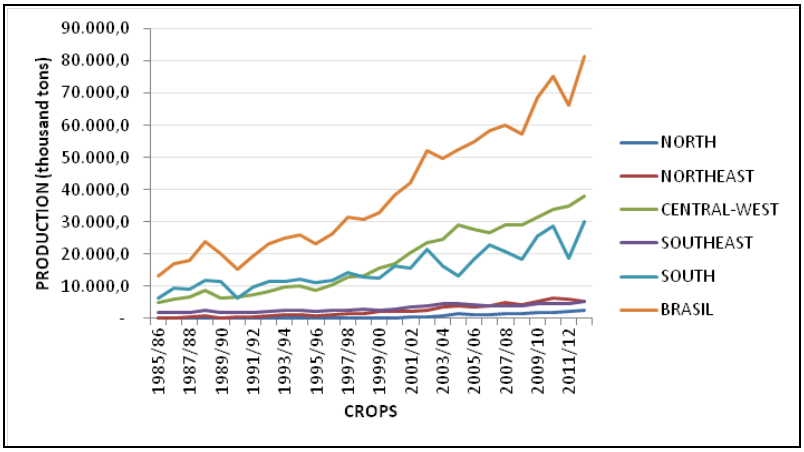
Source: CONAB (2014).

Figure 4. Soybeans Planted Area



Source: CONAB (2014).

Figure 5. Soybeans Production



Source: CONAB (2014).

There was also an increase in the number of cultivars: while from 1990 to 1997 only 66 soybean cultivars were launched (De Almeida, Wetzel and Ávila, 1999), in 2001 alone 59 new soybean cultivars were added to the Brazilian National Cultivar Registry (Registro Nacional de Cultivares, RNC). From 1998 to 2012, 526 soybean cultivars were registered with the RNC[3] (Lima, Silva Filho and Oliveira, 2013).

Table 1. Number of Cultivars Registered with the RNC

Year	No. of Soybeans Cultivars[(1)]
1998	186[(2)]
1999	25
2000	25
2001	59
2002	16
2003	38
2004	28
2005	25
2006	10
2007	29
2008	13
2009	25
2010	12
2011	25
2012	10
TOTAL	***526***

[(1)] Registered before the RNC from Dec 1998 to Dec 2012.
[(2)] This number considers the registration of cultivars that were created before the promulgation of the LPC and were registered on the RNC as soon as the legal protection began.

Source: Embrapa (2013).[4]

By 2012, Embrapa already had partnerships with more than 100 research institutions, of which 58 percent were universities, 17 percent were State Organizations of Agricultural and Livestock Research (OPEAS), 16 percent were private companies, and 9 percent were research institutions, both national and international (Lopes et al., 2012).

[3] The 1998 figure includes the registration of cultivars existing prior to the promulgation of the LPC and previously registered on the National Cultivar Registry (Registro Nacional de Cultivares).
[4] http://ainfo.cnptia.embrapa.br/digital/bitstream/item/87880/1/RESUMOS-XXXIIIRPSRCB-versao-eletronica.pdf

Embrapa's embrace of partnerships resulted in a steep decline in its market share of the seeds industry, here considered as a decrease in the area planted with Embrapa cultivars. Formerly the market leader with a 70 share, Embrapa now has a share of less than 10 percent.

Nevertheless, these figures do not necessarily reflect a threat to Embrapa. On the contrary: they are consistent with Embrapa's strategy and were part of a deliberate move. As a public R&D company, Embrapa aims to invest in fields other than those invested in by private companies, either because others are unable to invest in them or because those investments are unprofitable. After all, according to Embrapa's representative, public investments should not be made when they are "replaceable" by private capital, but only in fields where they are irreplaceable.

Bearing this in mind, it is reasonable to assume that the Cultivar Protection Law has favored the entry of several private firms into the Brazilian soybean seeds market since the late 1990s, pushing Embrapa towards a smaller and smaller market share. This means that huge public investments in the seeds market have been replaced by those made by private firms, hence freeing up a larger share of Embrapa's budget for alternative R&D projects differing from those in the private sphere. Therefore, this "capital replacement" has been beneficial, since it has allowed Embrapa to further develop different fields, which cannot be targeted by private competitors. The company nonetheless maintains its expertise in the development of new varieties of soybeans as a safeguard against any eventual monopolization of the soybean seed industry.

- *Measuring Capabilities*

Embrapa's capabilities have been measured and analyzed based on supporting stylized evidence, both with data collected from the company and discussed throughout this paper, and on secondary public information. These capabilities are illustrated in Table 2 below.

Table 2. Embrapa's Capabilities

CAPABILITY		Assessment of capabilities
Type of Capability	**Desirable outcomes**	
Technical	Scientific expertise	Number of PhDs, amount of innovation (consequence of a non-observed capability), low turnaround (learning by doing process)
	Bureaucratic efficiency	Bureaucratic structure provides incentives for technical qualification: i) employees can temporarily leave their positions in order to pursue formal education; ii) low turnover creates incentives for investments in specialized human capital (related to basic agricultural research)
Organizational	Public-public coordination	CNPQ enouncements/tenders, MPA course, partnerships with public universities, regional units are related to local public authorities, coordination with MAPA, projects with the MDA.
	Public-private coordination	Evidence of difficulties faced by private entities when attempting to make agreements with Embrapa. This is Embrapa's weakness, as inflexibility hinders engagement with the private sector.
	Experimentation and learning	Statement 1: stability allows for the accumulation of knowledge; Statement 2: inflexibility shapes the incentive system (career path of researchers)
Political	Credibility	Evidence: whenever Brazil takes researchers to Africa, it takes Embrapa, despite the difficulties in contracting with this organization.
	Creation of support groups	Embrapa regional: creation of related associations that provide support. Despite the difficulty in contracting with Embrapa, private firms do support this organization.
	Protection against capture (public and private)	Inflexible structure. Embrapa's CEO has made his career in the company.

Source: Based on data collected in interviews and from publicly available sources.

Embrapa's most notable strengths are its scientific expertise and its credibility. This is not surprising given that, as previously noted, 18 percent of its researchers have a master's degree, 74 percent have a doctoral degree and 7 percent have post-doctoral degrees. These figures are particularly impressive considering that the company has almost ten thousand employees. Also as previously mentioned, Embrapa's low employee turnover and large number of innovations reinforce its technical capabilities, particularly its scientific expertise. It is thus hardly surprising that the company enjoys a high level of credibility in Brazil. Brazilian agricultural missions to Africa, for example, usually include Embrapa representatives and researchers. If Embrapa were not so credible, other teams could be selected.

Embrapa is additionally strong in bureaucratic efficiency, since i) the company encourages employees to improve their technical qualifications, particularly by allowing them to take leaves of absence for additional training; and ii), the company has a low level of employee rotation (turnover), which generates incentives for investments in specific human resources related to agricultural basic research. These incentives benefit both the employee and the company itself: because the staff member knows that his/her position will be guaranteed after having acquired additional qualification, he/she will neither be afraid to look for these opportunities nor to overspecialize in a given field; and because the company knows the employee will remain there for a long time (and therefore allow it to reap the rewards of investing), it can afford to retain highly specialized personnel and provide incentives for further qualifications. Embrapa's overall technical capabilities are consequently quite strong.

While Embrapa's political capability does not equal its credibility, neither the company's autonomy in relation to public and private entities nor its ability to create support groups should be overlooked. Embrapa benefits in this regard from its reputation as a highly independent entity with little interaction with other parties beyond what is needed to undertake its programs and research. The creation of related associations by Embrapa's regional units, for example, demonstrates the company's ability to create support groups, while the finding that Embrapa's current CEO has made his career inside the organization underscores the company's autonomy.

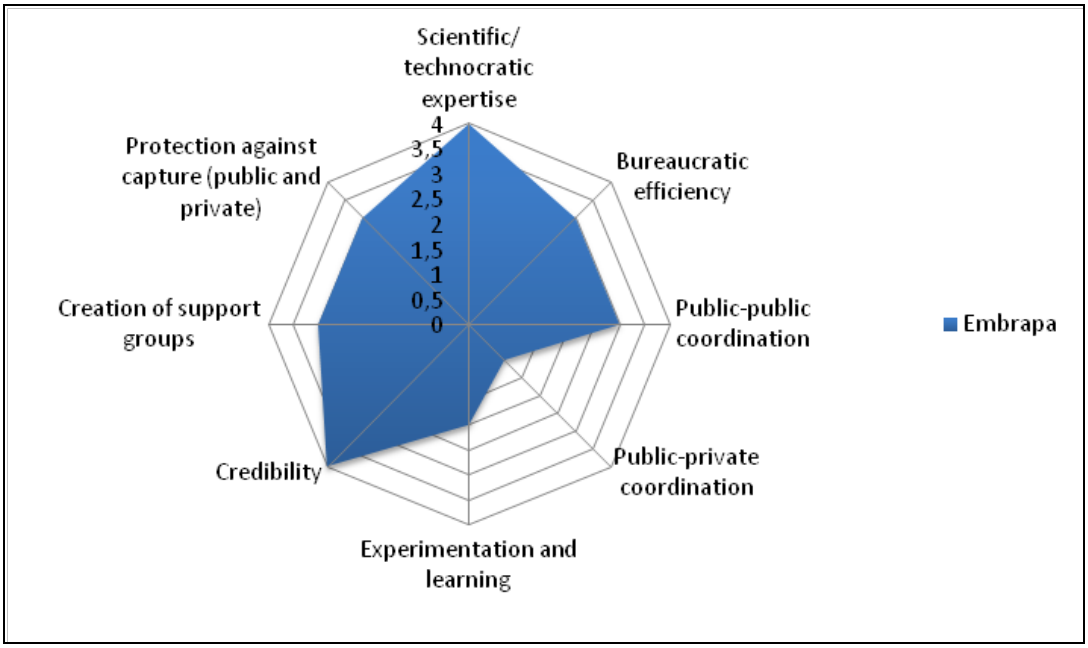
Embrapa's most conspicuous weakness is its difficulty in relating to the private sector. Despite an increase in partnerships with private companies, Embrapa struggles with the bureaucratic procedures that it has to follow as a state-owned enterprise subject to Law No. 8.666. While its regulatory rigidity provides the stability that enables Embrapa to accumulate knowledge in the long term, its inflexibility and difficulties in adapting agreements and relations to the peculiarities of each case constrain its ability to contract with private companies. In fact, bureaucratic constraints must be weighed against all of Embrapa's capabilities, as they prevent rapid adjustment and create difficulties in developing public policy, undertaking partnerships, and publishing research findings, among other considerations.

Embrapa has experienced far less difficulty in establishing partnerships with other public entities. It has undertaken a large number of agreements with public organizations ranging from universities to governmental ministries and agencies.

Embrapa displays somewhat more limited capabilities in experimentation and learning. The inflexible nature of the career path in the organization favors the accumulation of knowledge, even though this might not happen as the organization desires. Researchers themselves are nonetheless rewarded for experimentation and learning as they desire, in terms of both quantity and of quality.

In short, Embrapa's weaknesses in contracting with private firms and in experimentation and learning cause its organizational capabilities to be rated lower than those of the other two types. These analyses of the organization's capabilities are depicted in Figure 6.

Figure 6. Embrapa's Capabilities



Source: Authors' compilation.

It is interesting to point out that the graph has not been uniformly filled in, which would reflect similar levels for all capabilities. Instead, differences in coloring reflect differences in strength across capabilities. For instance, while the top left side of the graph has been filled in to reflect either high or intermediate degrees for technical and political capabilities, the lower right half of the picture has remained almost blank, reflecting weaknesses in organizational capabilities. Moreover, a graph of this sort makes easy to visualize that there have been

variations in levels of individual capabilities even within the same general group (i.e., technical, political or organizational capabilities).

3.1.4 Final Analysis and Comments: The Case's Contributions

This case demonstrates that it was not only necessary to obtain capabilities that were not available inside the organization, but also to find those capabilities in the private sphere (in this instance, Monsanto). This experience provides insights on the role of private companies in the effectiveness of public development policies.

As we have argued above, the main reasons leading to those partnerships seem to be resource constraints (i.e., focusing public investments on fields different from those performed by private firms) and complementary capabilities (i.e., finding synergies that lead to the desired innovation). In this case we have focused primarily on the latter because of the theoretical and practical implications of our findings.

In theoretical terms, they challenge the mainstream resource-based view (RBV) perspective favoring the vertical integration of all strategic capabilities. Our findings much more closely approach the "modern RBV," which advocates hybrid modes of organization to provide all the necessary strategic capabilities.

Second, and perhaps more intriguing than the former implication, is the finding that the three groups of capabilities—technical, organizational and political—are not totally independent of each other. We have instead found that they have interactive effects, so that the development of one particular type of capability depends on the others.

Even beyond this interdependence, we have surprisingly found a phenomenon resembling a tradeoff between technical and organizational capabilities at Embrapa: while they are both related and needed for effective innovation, it seems that the technical capabilities are enhanced by the inflexibility of the company relative to its organizational processes. Were they to be relaxed and become more flexible, technical skills would be sacrificed.

On the other hand, according to representatives of other enterprises interviewed for this study, as Embrapa is bureaucratic and subject to control mechanisms, it is sometimes hard or even impossible to contract with. As a result, some desirable partnerships never occur, despite complementary capabilities. This means that the tradeoff we have found both fosters and prevents hybrid modes of organizations as a means of obtaining the necessary capabilities for

effective and efficient innovation. The extent to which this becomes possible depends on having the "right" balance among "conflicting" capabilities.

In practical terms, our findings have indirectly revealed the role played by private companies in the technological development process. First, and most obvious of all, because Embrapa seeks to invest in fields different than those emphasized by private firms, the public company is allowed to focus its budget on other projects, either because they are unprofitable to private firms or because private firms are not capable of undertaking those projects themselves.

But most importantly, because of their different strategic orientations, private firms like Monsanto have developed distinct strategic capabilities relative to public companies such as Embrapa. In this respect, one can especially highlight the organizational capabilities required in order to rapidly respond and survive competitive pressure. These capabilities seem to complement those in public firms, thus illustrating the important role of these companies in the delivery of public development policies.

3.2. FINEP

Finep, the Brazilian Innovation Agency,[5] founded in 1967, is a state-owned company under the direction of the Ministry of Science, Technology and Innovation (MCTI). Its mission is to "stimulate economic and social development through the public support of Science, Technology, and Innovation in companies, universities, technological institutes and other public or private institutions."

During the 1970s Finep promoted intense mobilization in the scientific community and the creation of new research groups, the expansion of S&T infrastructure, the creation of thematic programs and the consolidation of graduate studies in the country. The 1980s, however, saw the amount of resources decrease through successive cuts in government expenditure that limited Finep's ability to maintain its investments. The 1990s were marked by an even harsher crisis caused by severe fiscal restraints.

As a result, in 1999 the sectorial funds were created as a new strategy to ensure financial resources and to guide the Innovation Policy in Brazil. Finep was made responsible for managing the funds and for acting as the Executive Secretariat of the National Fund of Scientific and

[5] In 2014, Finep's name was changed from "Financier of Studies and Projects" to "Brazilian Innovation Agency." In practice, its responsibilities remained the same.

Technological Development (FNDCT). This mandate notwithstanding, throughout the 2000s these funds were plagued by difficulties in resource transfers and inefficiency in monitoring the execution of projects. Financial resources could not be allocated from one sectorial fund to another, and there were restrictions on allocating non-refundable funds directly to firms. As a consequence, the main beneficiaries of Finep's projects were universities and research institutions rather than firms, the locus of innovation in industrial sectors. Moreover, according to two former directors, Finep personnel lacked the expertise required to evaluate and discriminate eligible projects. Therefore, even though the funding problem has been solved, money was not allocated efficiently.

A partial solution was found in 2011, when Finep, together with the Ministry of Science and Technology and the National Industry Confederation (CNI), led the creation of a new PDA, Embrapii (Brazilian Company for Industrial Research and Innovation). The new management model brought about by this institution changes the relationship between S&T institutions and companies. The creation of this new PDA, Embrapii, is the episode that will be investigated in this section

Embrapii differs from previously existing organizations through a new management and execution model designed to speed up delivery of resources and ensure excellence in operations through complementarity with private companies. As a Social Organization, Embrapii benefits from a degree of flexibility that Finep does not enjoy. Under Federal Law No. 9637, the Executive may designate as Social Organizations nonprofit legal entities whose activities are involve education, scientific research, technological development, protection and preservation of the environment, culture and health. These entities can enter into management agreements that are not subject to the same rules as those that govern the management of human resources, budget and finance, procurement and contracts in Brazilian public administration.

3.2.1 Historical Context and Description of the Episode

This case study is peculiar, as the episode chosen for in-depth analysis of the PDA (Finep) was the creation of new PDA (Embrapii). Before examining the creation of Embrapii, we present the timeline of facts that preceded it. As a first attempt to ensure the supply of credit to enterprises, Finep had created the Sector Funds (henceforth FS). After more than a decade struggling to fund innovations in firms, Finep concluded that it was necessary to create a new organization with

distinct capabilities to evaluate, contract and monitor funding of innovation projects. To better understand the rationale for the creation of Embrapii, this section discusses Finep's history and how it led to the creation of a new PDA.

FINEP

Finep, the Brazilian Innovation Agency, was founded in 1967 with the aim of institutionalizing the Fund for Financing Studies of Projects and Programs, created in 1965 as a substitute for the Fund of Technical-Scientific Development (Funtec), inaugurated in 1964 and managed by the Brazilian Development Bank (BNDES).

At that time, under the Import Substitution Industrialization model, Brazil was equipped with various instruments for the execution of industrial policy projects. One of these instruments was the creation of the National Fund of Scientific and Technological Development, FNDCT,[6] whose executive secretariat was put under Finep's charge.

The strategy that guided the creation of sectorial funds consisted of changing from a focus on the production of knowledge within the universities, research institutes and state-owned banks networks to the granting of loans to companies through partnerships with STIs (Institutes of Science and Technology) or via credit subsidy.

- *Finep's Support of the Creation of Embrapii: Background Information*

The creation of Embrapii is a response to the failure of policies implemented in the 1990s and early 2000s, particularly regarding the use of sectorial funds. The creation of sector funds in 1999 was led by the Federal Government, assigning Finep responsibility for its management and the function of Executive Secretariat for FNDCT. The main players were the Ministry of Science, Technology and Innovation (MCTI), Finep, and the National Council for Scientific and Technological Development (CNPq), which were responsible for contracting projects in accordance with the Managerial Committees' guidelines for each fund. Appendix 3 presents Sector Funds' institutional framework.

Results, however, fell far short of expectations, particularly with regard to the gap between the estimated and the executed disbursements. As pointed out by Melo (2009), in an extensive analysis of Finep's and FNDCT's activities, the average yearly disbursement was

[6] Decree-Law Nr. 279, July 31, 1969.

larger in the period from 1967 to 1997 than in the period from 1998 to 2006 despite the increase in resources made available by sector funds. The author suggests that, besides the unequivocal difference in international context between the two periods, flaws in governance played an important role as well. Finep lost autonomy with regard to employing resources from Fndct, and discretion in this matter was allocated to the Ministry of Science and Technology, where Finep has only a minority vote in managerial committees. Moreover, according to Hollanda (2010), sectorial funds could not be used to support projects of higher relevance or promote stronger cooperation between companies and institutions, resulting in low participation in this type of operation relative to the total amount of resources.

The reasons for the underperformance in the direct funding for relevant innovation in firms were twofold. First, nonrefundable grants could not be allocated directly to firms due to state control mechanisms. Funds could be allocated to universities and research institutes in projects undertaken in cooperation with private companies, but incentives to trigger this type of partnership were not in place. As a consequence, two-thirds of the funds ended up in research institutions, with little or no impact on innovation in firms. Second, Finep's staff did not have the required expertise to screen the best projects and to effectively monitor funding contracts in order to maximize firms' innovation efforts. Due to the diversity of technological knowledge, which tend to be quite specific to industrial sectors, and the fact that relevant innovations tend to use firms idiosyncratic and tacit knowledge, Fineps personnel could not acquire the technical capability needed to evaluate and monitor projects.

- *The Creation of Embrapii*

In 2011, Finep, together with the Ministry of Science and Technology, took the first steps in the creation of Embrapii and the reform of the Brazilian Innovation System. After two years of preparation, which included a pilot experience within Finep, Embrapii was formally created in 2013. The main pillars of the Embrapii System are meeting current demands, fostering technological innovation, and the continuous accumulation of technological capabilities. Embrapii, set up as a nonprofit civil association and designated as a Social Organization (SO),[7] seeks to explore the synergies between technological research institutions and private companies

[7] http://www.planalto.gov.br/ccivil_03/leis/l9637.htm

in Brazil. It focuses on meeting the needs of business through cooperation with both public and private institutions, aiming at risk-sharing in the pre-competitive stage of innovation. Furthermore, the company has more flexible funding and its own project hiring rules.

Embrapii works with a tripartite model that provides stronger incentives for cooperation between research institutes and firms and at the same time makes innovation funding faster and more flexible. It mobilizes one third of the resources needed for the project, with the rest divided between the convened research institute (STI) and the firm that is interested in innovation.[8] In addition, units accredited by Embrapii and partner Innovation Centers[9] are in charge of the management of each project and its financial execution, giving more responsibility for the results specified in the Plans of Action agreed upon. This is certainly the main difference with regard to Finep, whose budget execution had no clear monitoring system.

Two cases have inspired Embrapii's operating model. The first is Germany's Fraunhofer-Gesellschaft, in charge of 60 research institutes for industry-oriented technological innovation, developing new design for existing products as well as updating production methods. To hire Fraunhofer, one third of the resources must come from the interested company and the rest is divided between the Foundation and the German government, which is exactly the model adopted by Embrapii.

The second is Embrapa, whose case study was presented in the previous section. The reference to Embrapa, though, is limited to the aim of building a PDA that transforms innovation in a particular economic sector. Its operational model and governance structure is quite distinct from that chosen for Embrapii, which more closely follows the Fraunhofer-Gesellschaft experience.

At a September 7, 2011 hearing at the Chamber of Deputies, secretary for technological development from the Ministry of Science and Technology and Innovation (MCTI),Ronaldo Mota stated Embrapii would "aim to speed up and facilitate the innovation process, which is interrupted between the production and the negotiating phase, thus starting to operate in such range as Embrapa does."

[8] More precisely, responsibilities are shared as follows: Embrapii will contribute at most one third; and companies, at least one third. The rest is provided by companies.

[9] The creation of 40 Innovation Centers is part of the Federal Business Innovation Program in partnership with the Ministry of Education and the Ministry of Science and Technology.

The pilot project began in 2011 when the cooperation agreement between Finep, the Ministry of Science and Technology (MCTI) and the National Industry Confederation (CNI) was signed. In 2012 it effectively started through the cooperation terms between CNI and three research institutes: the National Institute of Technology (INT/MCTI) in Rio de Janeiro; Institute for Technological Research (IPT) in Sao Paulo, and the Integrated Center for Manufacturing and Technology (Cimatec) of the National Service for Industrial Apprenticeship (Senai). The first term for the implementation of this initiative was 18 months, but it was subsequently extended six extra months for a total of 24 months in which these institutions could seek out projects for the pilot experiment, with an equal period for the execution and the conclusion of projects. This first stage, which precedes the creation and the official inauguration of Embrapii itself, involved monthly meetings for monitoring and documenting the experience under the coordination of CNI. Next, we explain briefly the role of each institution in order to make their capabilities clearer.

The Institute for Technological Research (IPT) is linked to the Secretariat for Economic Development, Science, Technology and Innovation of the State of Sao Paulo in the Brazilian Southeast, an important and dynamic development region in the country, and it is noted for being one of the country's most important research institutes, providing technological solutions and meeting demands for services from both the private and public sectors. The institute, made up of 11 technological centers, has modern laboratory facilities and a highly qualified research and technical staff, acting in four main areas: innovation, research and development, technological services, metrological support and development, and information & education in technology. Moreover, the areas of nanotechnology, new materials, light steel framing and bioenergy are being expanded. The pilot project in this institution specifically involved the competences of Bionanomanufacturing/Materials.

Cimatec is an Integrated Campus of Manufacture and Technology located in the city of Salvador, Bahia in the Brazilian Northeast, and its main goal is to meet industry demands via labor training, technical and technological services and applied research. It stands out as an important center for skilled labor training in automated industrial processes and applied research, in particular in computer-integrated manufacture. The pilot project in this institution specifically involved the competences of manufacturing automation.

Finally, the National Institute of Technology (INT), located in Rio de Janeiro, also in the Brazilian Southeast, was founded in 1921 with the goal of promoting research, development and innovation actions, industrial technology and technological services. Currently, the technical competence of INT involves the Catalysis and Chemical Processes, Corrosion and Degradation, Industrial Design, Energy, Evaluation Engineering, Production Management, Technological Information and Prospection, Materials Processing and Characterization and Analytical Chemistry. Its infrastructure includes several laboratories that are national leaders in their respective areas, following rigid standards of metrology, standardization and industrial quality.

Finally, the competence areas of each STI in the pilot experience were not as rigidly classified into sectors as they were under the sectorial funds. This approach protects the interests of each STI and subsequently that of the companies with whom agreements are signed. IPT adopted Bionanomanufacturing/Materials, INT adopted Energy and Health, and Cimatec adopted Manufacturing Automation in the pilot stage of Embrapii. In February 2014 there were 11 projects approved with signed contracts, and another 88 in development. In IPT, the total value of approved projects with signed contract was more than R$25.16 million, and more than R$74.22 million for Senai/Cimatec.

In 2014 the first public call for Embrapii units accreditation was launched with the expectation of selecting at most 10 scientific and technological research institutions, either public or private nonprofit. The first step is to verify the eligibility of each institution according to the terms established in the public notice. In a second step, each STI submits an action plan. The technical staff responsible for selecting and monitoring projects is made up of renowned external specialists in the competence areas for which the STIs apply.

3.2.3 Episode Outcomes: Embrapii

In order to identify the effect of the episode on capabilities, we compare Finep and Embrapii's capabilities before and after the creation of Embrapii and how those capabilities might have affected the success of the policy implemented based on results from the pilot project.

The Ministry of Science of Technology delegated to Finep the creation of Embrapii and encouraged it to undertake Embrapii's pilot project in partnership with the National Confederation of Industry (CNI). The objective of Embrapii is to foster collaborative projects between firms and STIs to generate innovative products and processes, and during the execution

of the pilot project with the three Brazilian STIs, the new institutional design worked well, particularly in triggering partnerships between research institutes and companies. The most important results from the creation of Embrapii were the following.

- The execution of the new action plan, negotiated with the CNI and the Federal Government, created a need for expanded capabilities for the STIs. Research institutes typically possess technical capabilities, but they have lacked capabilities to prospect opportunities for innovation in partnership with firms, and to negotiate and carry on complex contracts related to intellectual property. During the pilot experience, the STIs had to create these capabilities by allocating and training personnel for these activities.
- Partnerships between STIs and companies allowed both parties to build new capabilities. STIs, for example, benefited from widening their understanding of the market involved in each project, an important advance given the disconnection between theory and practice in the Brazilian higher education system. This technical capability in the form of new expertise and stronger links among stakeholders facilitates the formation of a technical staff that will be able to apply more effectively its expertise to solve relevant and real problems.
- The standardization of Embrapii's operating model provided operational benefits to STIs such as process controls, contracts and execution of projects that did not exist previously. Therefore, among the capabilities that were encouraged, organizational gains made the largest gains.
- Since Embrapii imposed a strict deadline for the execution of each project, this created the need for more effective administrative control in the STIs in order to avoid payment suspension. Interviewees claim that the experience improved process standardization as well as the allocation of human, administrative and financial resources within STIs. As a result, the new institutional design resulted in the acquisition of the capabilities of "public-private collaboration" and "experimentation and learning."

IPT's experience illustrates those changes. Of the 10 contracts[10] signed in June 2013, amounting to R$23.4 million, six projects involve nanotechnology, two involve biotechnology, one involves micro-manufacturing and one involves new materials. Moreover, the institute's total revenue associated with innovation projects increased from 13 percent in 2010 to 21 percent in 2012. As IPT pilot program coordinator Flávia Motta states, "the partnership with Embrapii enabled more dynamics to projects. Now we can show a financial and technological solution to companies, with an already approved funding."[11]

The creation of Embrapii additionally allowed Finep to acquire new capabilities. Notable changes in the latter include the following: i) greater synergy and connection among various players in the National Innovation System with the formation of managerial committees including representatives from ministries, development agencies, the scientific community and the business sector; ii) modernization of financial instruments through fund management with more stable funding sources; and iii) flexibility imposed by the division of funds among strategic sectors.

STIs, for their part, must display the following capabilities to be accredited as project executors:

- Facilities and infrastructure that permit the execution of action plan reported in the project in partnership with manufacturing companies.
- Qualified technical staff for the proposed activities.
- Highly qualified project managers with some experience with cooperative projects. The existence of metrics and managerial tools represents a differential, since STIs meet not only business demands, but also research their own research demands.
- Multidisciplinary technical staff for company and projects prospection.

[10] Natura works in the cosmetics, fragrance and toiletry market; InterCement is a holding for cement business of the Camargo Corrêa group; Iharabras Chemical Industries has a line of agricultural products and also one for control of pests, such as fungicides and herbicides; Elekeiroz is a company of chemical compounds for industrial use; TheraSkin is a pharmaceutical industry; the Institute of Technology and Studies of Cosmetics, Toiletry and Fragrance is the technological axis of the Brazilian association of the sector, and reunites in a cooperative project Natura, Grupo Boticário and Yamá, the latter ones also working in the beauty market. Angelus is the only small business until now in the pilot stage of the EMBRAPII project with IPT, developing solutions for dentistry products.

[11] Available at: http://www.usinagem-brasil.com.br/8583-EMBRAPII-investira-r-260-mi-em-projetos-de-inovacao/ Accessed in May 22, 2014.

- Capabilities in intellectual property rights negotiation, since companies and STI are co-owners of the intellectual property resulting from the project.

The capabilities acquired in the creation of Embrapii changed the way research institutes and companies interact with the PDA and, ultimately, how they innovate. Before the episode, STIs (or much more rarely, companies) independently submitted project proposals, usually involving funding requests, to separate divisions of Finep. Since the creation of Embrapii, STIs and companies have shared all the stages of the innovation process, generating new organizational skills that are more conducive to triggering innovation within firms.

The creation of Embrapii also allowed for a substantial change in the management model. While Finep selects projects via public calls and monitors the stages of research via regular reports,[12] in Embrapii's model STIs are active in all stages of the process, from application to final execution. Therefore, they are in charge of negotiating with business sectors on every aspect of the project to be undertaken, remodeling its design when necessary and selecting which products and/or services will be developed.

Moreover, Finep is subject to control mechanisms that stifle the execution of the project, making it difficult to implement adjustments that would benefit ongoing R&D. Each modification must be approved by the financing entity and its technicians, which is time consuming. In the case of Embrapii, the relationship is more flexible, as it is established by each STI-company pair, which allows for remodeling the project when necessary. This feature is important for the execution of projects, since innovation activity is essentially marked by uncertainty and extreme dependence on previous stages.

Keeping a contract of attributions along with the government and having a pre-established budget encourages Embrapii to pursue efficiency in its resource management. In addition, Embrapii's executive board includes members with private sector careers marked by efficient management and accomplishment of specific goals, making this new entity particular pragmatic in character (see Appendix 3 for details on Embrapii's governance structure).

[12] The technical and financial monitoring of the supported projects is carried out by Finep or a designated entity, via monitoring visits, technical meetings or other assessment mechanisms, at the discretion of Finep.

- *Measuring Capabilities*

Following the classification of capabilities presented by Cornick (2013), Table 3 summarizes the main facts that support each capability assessment and subsequent measurement. As this is a peculiar case, in which the selected episode was the making of a new PDA, the assessment takes into account the capabilities of both Finep and Embrapii.

Table 3. Finep/Embrapii's Capabilities

CAPABILITY		Assessment of capabilities
Type of Capability	**Desirable outcomes**	
Technical	Scientific expertise	Neither Finep nor Embrapii possesses extensive scientific expertise. The PDA has to interact with industrial sectors possessing distinct types of technological knowledge, which makes it difficult to accumulate expertise and benefit from sufficient scale in each technological paradigm.
	Bureaucratic efficiency	Finep's bureaucratic structure does not provide incentives for technical qualification (as compared to Embrapa). To deal with this (intrinsic) limitation, Embrapii relies on technical specialists from other organizations in ad hoc committees.
Organizational	Public-public coordination	Finep, by means of public calls, is able to foster innovation in universities and research institutes. For the creation of Embrapii, Finep also had to interact with the ministries of Science and Technology, and Education. However, this type of interaction is rather sporadic.
	Public-private coordination	The most outstanding capacity of Finep/Embrapii stems from the tripartite model adopted by the latter. The pilot project showed that the PDA is now able to trigger innovation within firms in collaboration with research institutes.
	Experimentation and learning	The creation of Embrapii is an illustration of successful experimentation and learning. However, this achievement was the result of Finep's head at the time and not a feature embedded in the organization.
Political	Credibility	Embrapii, although so far a successful experience, has not yet had time to build notable credibility among its stakeholders. It is not yet a well-known organization.
	Creation of support groups	Embrapii's governance design brings together interest groups that have political power (e.g., trade associations, industry confederation) and legitimates the PDA and the continuity of its activities.
	Protection against capture (public and private)	The political support from trading associations protects Embrapii against capture by public agents or discontinuity due to changes in the incumbent political group; but for this reason Embrapii is relatively weaker as for private capture. To mitigate private capture all decisions are fully transparent.

Source: Based on data collected at the interviews and on publicly available information.

Finep/Embrapii stands out for its political and organizational capabilities. The following features support this assessment: i) public-private coordination is the very essence of Embrapii's model; ii) as a Social Organization Embrapii is flexible, which enables it to manage its contracts more effectively; iii) support groups were created to improve monitoring, such as the follow-up committee composed of specialists, industry representatives, and Finep or CNPq; and iv) Embrapii's board is made up of industry representatives who possess not only expertise, but also strong political support from trading associations, which protects Embrapii against capture by public agents or discontinuity due to changes in the incumbent political group. On the other hand, while Embrapii is relatively weaker against private capture, meanwhile, Finep is more vulnerable to public capture, since public calls are at discretion of the Ministry of Science and Technology. Moreover, Embrapii does not possess technological capabilities, which are located in firms and research institutes. The lack of internal technical expertise is mitigated by the use of ad hoc specialists invited to participate in follow-up committees.

Regarding political capability, it is noteworthy that CNI was made a stakeholder through its Entrepreneurial Mobilization for Innovation Board. This legitimizes Embrapii and brings the political support of industry and trade associations to the maintenance of Embrapii and its policies, which strengthens its capability to create support groups. Embrapii's credibility is further enhanced by its public calls, high-level communication skills and organizational design. However, this PDA has not yet had time to develop its reputation among stakeholders.[13]

Finally, protection against public and private capture can be effective through a new governance structure. As for public capture, politicians do not have discretion to affect Embrapii's actions directly due to its governance and the role of the board. As for private capture, it is still unclear if interest groups will be able to distort Embrapii's actions. To mitigate private capture all decisions are fully transparent and monitored by the board with government, research agencies and industry representatives.

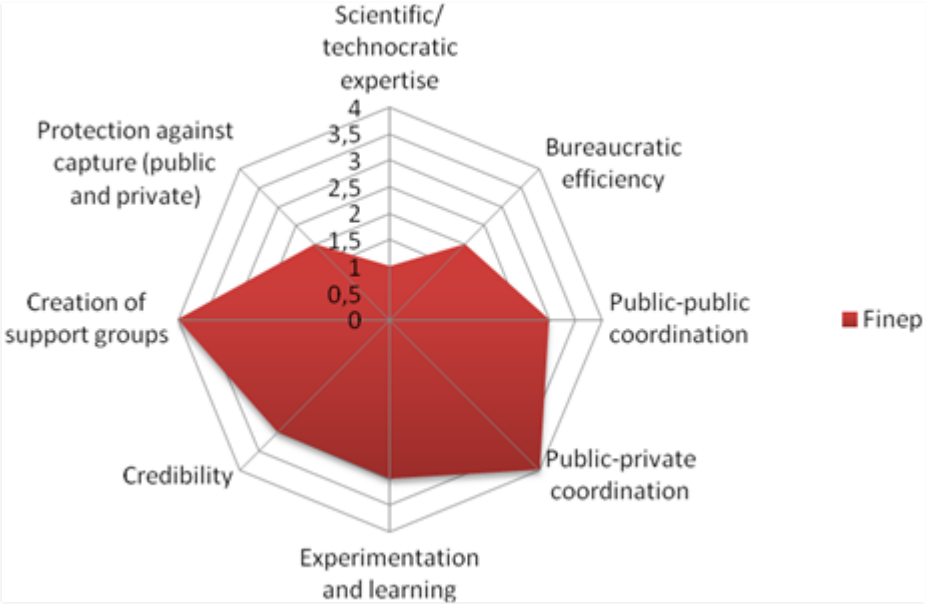
Lastly, in regard to organizational capability, Embrapii's public-private coordination is highly evaluated, and this capability is at the heart of its tripartite model. Since innovation projects—especially those that involve intellectual property rights negotiation—require mutual trust between the parties, ex ante contact between companies and STIs is valuable, enabling

[13] Embrapii has been fully operational since October 2014.

companies to choose the partner with which it would execute each project. Embrapii has been able to trigger such interactions with a model that preserves flexibility, but induces cooperation. As for public-public cooperation, Embrapii's creation improved the allocation of sectorial funds, a major problem during the 2000s. With respect to "experimentation and learning," the creation of Embrapii and its first stage as a pilot project directed by Finep is itself evidence that Finep has learned from previous experiences in the 1990s and early 2000s. However, this achievement was the result of Finep's head at the time and not a feature embedded in the organization.

The assessment of Finep/Embrapii's capabilities is illustrated by Figure. The conversion of qualitative information to a scale that quantifies capabilities followed the methodology presented in Section 2.

Figure 7. Finep's Capabilities



Source: Authors' compilation.

3.2.3 Final Analysis and Comments

Public policies on technological innovation in Brazil have always been based on the belief that funding innovation depended on overcoming financial constraints. Whether in manufacturing or the agricultural sector, innovation is an important factor in enhancing productivity and hence

sustainable development. Until the early 1990s, however, science and innovation policy had been for the most part oriented to universities or research institutes (STIs) and did not involve the business sector. The creation of Finep-managed sectorial funds in the late 1990s, however, resulted in new financing instruments that directed resources to companies as well as other entities.

In seeking sectorial funds, STIs submitted innovation projects according to specific public calls in each fund's subject are. Companies taking part are first required to establish partnerships with STIs and then execute cooperative projects in differentiated conditions more advantageous than those prevailing in the market. Hence, whether through Finep or other institutions, companies would engage only in activities with an ensured return sufficient to meet the costs of the financing contracted. Sectorial funds, however, financed only projects, not companies. Therefore, besides needing to operate in specific sectors, companies would be subject to bureaucracy that stifled execution, as approval and technical reports were needed when any modification had to be made. Finally, resource delays within the institution prevented resources from reaching their target. In this setting, the most technologically intense projects lacked the financing mechanisms that would have encouraged companies and research institutions to propose partnerships. While funding for innovation was available, it was still difficult to attract the most qualified projects.

This situation led to the creation of Embrapii, a joint effort of business representatives (CNI), the Ministry of Science and Technology and other public organizations, partly particular Finep. The new model selects STIs that would be free to seek out companies based on business demands to execute innovation projects.

The greater organizational flexibility promoted by the new management model led to the creation of new competences within the STIs involved in the pilot. Some of these new capabilities developed in response to Embrapii requirements, whereas others arose from interaction with the companies that initiated the projects. The new management model was validated by the rapid expansion of those new competences, automatically strengthening the position of the STIs in the pilot project as Embrapii units. In this first stage, Embrapii approved 68 projects in the areas of manufacturing, automation, bionanotechnology, health and energy, which amounted to R$188 million, of which R$62 million came from Embrapii.

The implications for public policy are clear: transparent governance practices can successfully be used to assemble complementary capabilities. Embrapii possesses notable advantages in this regard, combining contributions from the private sector (in its executive board) and from the state (funding, risk-sharing, and technological expertise in research institutes). The incentive to engage in cooperative projects requiring a clear division of labor constitutes a second advantage of Embrapii's model. In promoting resource division according to the competences of each STI and in delegating to them the task of seeking out companies interested in partnerships, the new arrangement allows for more effective, reliable and long-lasting cooperation based on the business rhythm of execution rather than the public calls calendar.

3.3. ABC Foundation

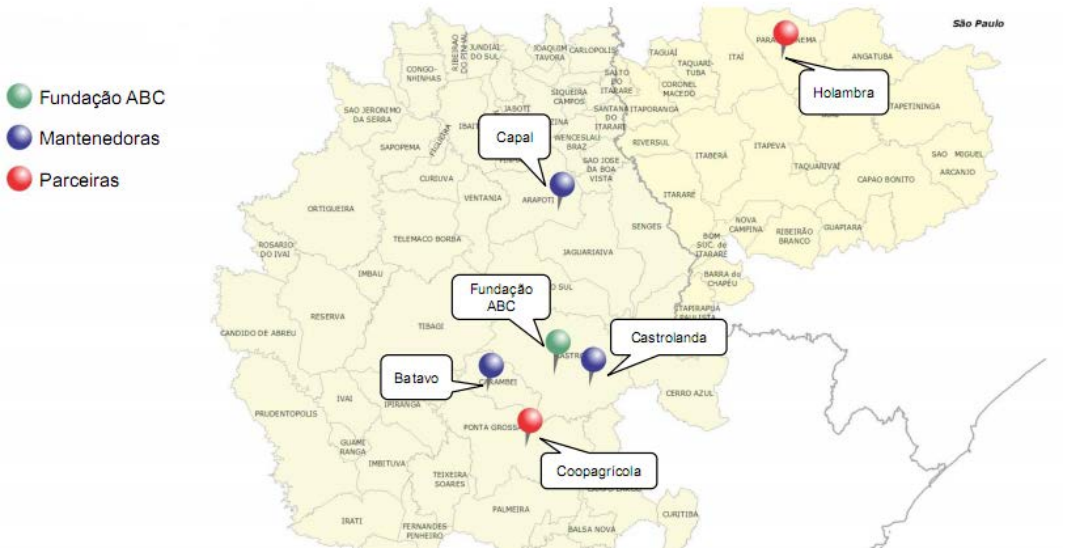
3.3.1 What is the Agency and Which is the Selected Episode?

The ABC Foundation for Technical Assistance and Dissemination in Agriculture is a nonprofit organization supported by contributions from producers and research partnerships with private companies, as well as from soil testing services, food science firms, and geographic information system firms. The foundation's aim is to provide technological support to farmers affiliated with the Agro-Pecuária Capal (Arapoti), Batavo, and Castrolanda cooperatives, which together form the ABC Group.

The Foundation was originally created on October 23, 1984 by the Central Dairy Cooperative of Parana (CCLPL), itself established in 1954 in the Campos Gerais region of Parana State in southern Brazil. Located in an area characterized by poor soil and low fertility, the Cooperative was created with the purpose of providing technical assistance to farmers of agriculture and livestock.

Figure 8 shows the geographical location of ABC Foundation, its sponsoring cooperatives, and its partners in Parana state. The Foundation presently operates in an area of 395,000 hectares. With farms in 67 municipalities, these cooperatives represent 2,671 farmers distributed as follows: Capal (1,242), Batavo (675), and Castrolanda (754).

Figure 8. Map Showing Locations of Sponsoring and Partner Cooperatives and the ABC Foundation



Source: ABC Foundation.

The ABC Foundation is an *organization of collective interest*, in this case operated under private management but oriented toward public policies. It promotes regional development through links with public and private organizations conducting R&D in agricultural inputs, though without the enforcement power of the state. By assuming the role of organizing the complementary capabilities of these entities, the ABC Foundation fills a niche where previously there was a lack of public policy for generating and disseminating new knowledge among farmers.

Although the ABC Foundation was launched with the purpose of developing techniques and agricultural systems to ensure the constant improvement of its members, at its inception the Foundation worked alone in the development and dissemination of new technologies for farmers. At the time, funds from the Brazilian agricultural credit policy and association members were sufficient for developing capabilities. In the late 1980s, however, the crisis that affected the Brazilian economy caused the stagnation of subsidized credit and brought about the need to access external capabilities to develop new technologies given the state of development that the region had reached. New strategies were thus required.

This case deals with how the Foundation managed to continue its strategy of regional development through the establishment of partnerships with private firms (multinational agrochemical and seed) and public entities, including Embrapa and universities that conduct R&D in this area.

The case makes clear that among the three bundled complementary capacities—technical, organizational, and political—necessary to implement public policies (Cornick, 2013), the ABC Foundation could most efficiently develop its organizational capacity in order to seek the collaboration of public and private inputs from research organizations. Partnerships among these organizations allow great flexibility in conducting research projects with long maturities since they are not required to seek resources from financial markets, with the attendant need to deliver short-term results.

The Foundation is considered a benchmark in terms of the technology applied and developed in its labs and experimental fields with its partners. As a result of this strategy, the average productivity of the region, once considered inhospitable for grain cultivation, already exceeds the average of the Corn Belt region in the United States, the largest reference area in grain production.

3.3.2 Historical Context and Description of the Episode

Since its establishment in 1958, ABC Foundation has operated a model farm for the testing and adaptation of new technologies. As most of the population was of Dutch ancestry, their knowledge at that time came from the Netherlands, and Dutch agronomists were invited to work in the region from time to time in order to transfer knowledge and techniques, since this region was characterized by poor soils and low fertility.

The cooperative was one of the pioneers in the development of no-tillage in Brazil. Based on work in the United States, and with the help of Dutch technicians, the practice became widespread in the Campos Gerais region. This system is a technique of conservation in which the soil is always kept covered with growing plants and plant residues. As this coverage is intended to protect soil from the impact of rainfall, water runoff, and wind erosion, the technique allows producers to undertake their productive activities in a sustainable manner. Despite the success arising from the ease of adoption of this technology, until the 1970s agriculture in Brazil remained for the most part based on the traditional system of land under tillage with plowing, harrowing, burning straw, and other soil-exposing methods.

The work undertaken became essential to some producers, who established the so-called "Earthworm Club." No-till farming without fire, plowing and harrowing became common for major crops, representing the return of fertility. Furthermore, the biggest problem, erosion, was solved. However, as some problems were solved, others appeared and solutions needed to be adjusted to the new technology that was being developed. For instance, during this period the Foundation's work on developing technology for its member was presented in isolation, and no projects were undertaken in partnership with external private or public research centers.

The critical moment for ABC Foundation came at the beginning of 1995. Up to that time its research had been financed by the ABC Group, i.e., its members. The Foundation had also up to that time benefited from a national policy of subsidized credit in which cooperatives enjoyed privileged access.

The economic situation of the country changed in the mid-1990s with economic opening, increased external competition and the Real Plan. These were difficult years, with depressed prices in the international market, and there was a need to provide results to the Foundation's producers. Accordingly, there was an understanding that the Foundation should enter the market's undertakings in this process so that it could jointly fund and develop technology. In addition, it was increasingly difficult to obtain further productivity gains based solely on the no-tillage system. New advances would require inputs that would demand capabilities and financial resources beyond those the Foundation already possessed.

In 1995, the board of the Foundation, headed by President Richard Borg and General Manager Marcos Ludovico Valentini, both agronomists, decided to search for partners such as multinational companies and public research centers developing cutting-edge technology programs. It was clear that the Foundation did not possess the in-house capabilities required to develop new and sophisticated solutions for increasing farms' productivity. It should also be noted that partnerships with multinational companies represented an innovation in Brazilian agriculture at this time.

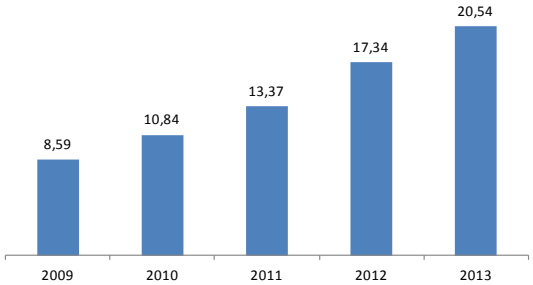
For the new model to be implemented, profound changes were made to the organization. These changes were important in order to incorporate additional "organizational capabilities," mainly those relating to coordination between cooperatives and private and public partners, and they have been adopted to allow the fast decisions and flexibility needed to engage in partnerships. The main changes are listed below.

1. *New organization chart*. A new organization chart gave more autonomy to area coordinators in applied research. Besides promoting the rationalization and centralization of decision-making, the measure served to create greater flexibility and more efficient administration.
2. *Centralization of field experiments*. Until 1995 each cooperative had operated its own experimental demonstration farm. To allow the building of partnerships with research centers, a centralization project was undertaken in which the Foundation took control of the experimental farms.
3. *Greater involvement of agronomists in policy research*. The Foundation adopted a model in which each producer group is assisted by an agronomist who reports on events and issues to the Foundation. These reports are used to target solutions and future research.
4. *Restructuring of the Department of Technical Assistance (DTA) and acquisition of Laboratory of Soils and Plants*. Two important measures adopted in this period were the redesign of the DTA, created in the 1970s, and the acquisition of the Laboratory of Soils and Plants from CCLPL. If the Foundation had not done so, the lab would have ceased to operate and the region would be without any service of this kind.
5. *Creation of "Technology Shows"*. With experimental demonstration farms now centralized, the Foundation's leaders and partner companies felt the need to organize a technical event designed to demonstrate technological outcomes that would serve the entire region. These shows serve as a showcase for the work of partnerships and features an area where the ABC Foundation presents its own work.

This model meant that the Foundation became much more independent. Its budget, which was initially 100 percent funded by producers, had the following proportion after four years: one third of resources comes from producers through annual fees paid by members of associated cooperatives, another third comes from partnership contracts, and the final third is obtained from areas of agricultural production and laboratories belonging to the Foundation.

In 2013 the budget of the ABC Foundation was R $20.538 million. As shown in Figure 9, the budget has increased by 139 percent from the 2009 total of R$ 8.591 million.[14]

Figure 9. Budget Evolution of the ABC Foundation, 2009-2013, in Millions of R$



Source: ABC Foundation.

As noted, the funding of the ABC Foundation is divided among several agents, including cooperatives, partner companies, and producers, as shown in Table 4. The two largest funding sources are cooperatives and their producers, followed by partner companies.

Table 4. Share of Revenue from Different Sources (Base Year 2012)

Source	%
Sponsors	33.66
Partner Companies	32.72
Provision of Services	20.39
Production CDE's	6.75
Producer Contributors	5.40
Other Revenue	1.08

Source: ABC Foundation.

[14] *Exchange* 1 USD Dólar = 2.16 *Real*.

- *Organizing Partnerships*

Partnerships are initiated in two ways: first, by the ABC Foundation based on a need to solve problems with their regional producers; and second, by private or public organizations in need of developing new products and technologies.

ABC Foundation's first partnership was initiated under the management of Richard Borg in the 1990s. ABC Foundation prepared a business model and sold it to multinationals operating in the inputs sector. As holders of new technologies, those multinationals were interested in developing new products and entering new markets. The first companies to cooperate with ABC Foundation were Bayer and BASF.

The process of entering into partnerships was fully explained to all managers within the Foundation and resulted in an initiative that was well accepted by the sponsoring cooperatives (Arapoti (Capal), Batavo, and Castrolanda). The need for the entity to undergo a transformation and take on very detailed projects encouraged the staff of both the Foundation and cooperatives to engage with the process.

The model works as follows, Partner companies present a project, and Foundation researchers evaluate the proposal, performing tests on the research farm and further analyzing the project's effect on producers. If the project is accepted, the partnership is initiated. Throughout this process there is interaction among Foundation researchers, researchers from private/public companies and producers in order to transfer knowledge and new technologies.

This process, according to its founders and former managers, was critical to the survival of the Foundation as an institution supporting the development and research of producers in the region of Campos Gerais, Parana, and other regions of the country. As mentioned above, the development of partnerships led to the creation of the annual "Technology Show," in which companies partnering with the ABC Foundation demonstrate to the market innovative projects and processes that are being developed together with the producers of sponsor cooperatives.

The partner organizations, shown in Figure 8 below, include both public and private entities. Among the public partners, Embrapa, IAPAR (Agronomic Institute of Parana), and universities stand out for their contributions. In the private sector, pesticide and/or seed firms such as Bayer, BASF, Dow, Syngenta, and FMC are of great importance.

Figure 10a. Public Partnerships

Source: ABC Foundation.

Figure 10b. Private Partnerships

Source: ABC Foundation.

Regarding incentives for adopting partnerships, the ABC Foundation for its part searches the market for new solutions and new tools for the region and its associated producers that are inexpensive and efficient and reduce environmental impact. This means that there is a demand for firms to develop new products and techniques and reach new markets. While private firms

have an incentive to open markets for their new products and technologies as well as actually develop them, they are especially drawn by the possibility of using the ABC Foundation's experimental farms. This asset attracts both private companies and public institutions to work with the Foundation. In the case of public partnerships with Embrapa and universities, the incentives lie in the fostering, resources, and infrastructure (field trials) that the ABC Foundation provides for developing technologies from research studies.

One example of a successful private partnership is the development of the AgroDetecta project with BASF. BASF together with the ABC Foundation develops knowledge, products, and technology, and BASF is responsible for passing these on to ABC Foundation producers. At the time of writing this project has been underway for three years, beginning with the ABC Foundation and expanding to BASF's global market.

According to ABC Foundation, one area where partnerships have not produced great results is the machinery sector. Although agriculture has a high demand for this type of input, there is little concern within the sector for development of and innovation in certain areas and crops. Under a different scenario, with a larger supply of machinery, there would be greater competition for markets, and the development of new techniques would lead to a greater focus on innovation and partnerships.

Private companies' constant pursuit of new opportunities and their agility in opening markets and developing products will continue to make partnerships of this type desirable. Embrapa, with its budget for this role and despite its bureaucracy, could offer greater potential for developing partnerships. For both the region and its producers there is a need for continuing research, and the Foundation promotes a search for partnerships. This provides a great incentive for Embrapa to undertake such projects.

During the initial opening of the ABC Foundation from 1995 to2000, the main aim of the partnership with Embrapa was to bring researchers to the Campos Gerais region and exchange ideas about innovations and new technologies. An important example of this partnership was gains from new varieties of corn adapted to the region's winter climate. Today this second "little crop" of corn has reached almost the same proportion and importance as corn grown during the regular season.

Throughout the process there have been continuing complementarities with Embrapa, which ultimately generate synergies between the two entities. Particularly notable is the

exchange of knowledge, as Embrapa laboratories perform analysis of ABC Foundation producers' output and the Foundation has access to Embrapa's highly qualified body of researchers. In addition, the Foundation offers Embrapa researchers the infrastructure to carry out research, especially its experimental farms.

One drawback to this kind of partnership is the slow process by which results are translated into practice. According the Embrapa case, Embrapa is not as flexible and fast to contract with as are private organizations. For the ABC Foundation to translate data into practical innovation, Embrapa requires that the data and laboratory tools first be published in scientific journals and conferences, a lengthy process that often derails the partnership due to the need for urgent results on the part of the cooperatives' producers.

The process is faster with universities. Researchers there are required to publish constantly, thereby speeding up the process, generating more data and mutual knowledge and often creating even more possibilities for publication, enhancing the flow of data as well as the partnership.

While there is synergy in the partnership between the ABC Foundation and Embrapa, and mutual desire to further their work, red tape and publishing rules cause the partnership to be underutilized. Embrapa researchers have provided intellectual knowledge, but the Foundation's infrastructure offers them insufficient support. It still remains for the combined resources to be used optimally.

3.3.3 Episode Outcomes

As pointed out, the ABC Foundation had to undertake a profound change in its internal structures in order to access the capabilities of external public and private organizations that undertake research in agricultural inputs. These changes led to the prioritization of investment in material and human resources, essential to fostering partnerships in research.

- *Building Internal Capacity to Access External Capacities*

Material Resources

With regard to material resources, the ABC Foundation has 11 laboratories in the areas of soil and plants, food science, environmental pathology, germination and seed vigor, nematology, molecular biology, and geographical and environmental information. The laboratories all bear

the Inmetro seal, which certifies their processes and allows access to inspections and audits when needed. Two laboratories—soil physics and industrial quality of wheat—have been awarded ISO 17025 certification, and the waste analysis laboratory has the seal of Good Laboratory Practice (GLP). These certifications attest to and certify that the Foundation employs accredited and high-quality standards to conduct analyses of research to develop products through producers and cooperatives' own laboratories. The Foundation has five experimental farms, all in Parana state, located in Arapoti, Castro, Itaberá, Tibagy, and Ponta Grossa, totaling 344.29 hectares. These sites are where the Foundation undertakes research and develops products with its partners.

Human Resources

The staff of the ABC Foundation, divided by areas, is summarized in the table below. From 2008 to 2012 there was a 113 percent increase in total number of employees, with research and support for producers and cooperatives the fastest-growing sectors at 119 percent and 112 percent, respectively. This increase stems from the strategy of seeking new techniques and offering assistance to producers. The research sector accounts for over 70 percent of Foundation staff, followed by support at 18.6 percent and services at 11.3 percent.

Table 5. Staff of ABC Foundation, 2008 to 2012

	Research	Support	Services	Total
2008	62	17	12	91
2009	75	18	15	108
2010	88	21	14	123
2011	111	31	19	161
2012	136	36	22	194
Variation 08-12	119%	112%	83%	113%

Source: ABC Foundation.

The Foundation's employees are a diverse group including two PhDs, three PhD students, 15 teachers, one master's student, 13 post-graduate students, six post-graduates, 12 graduates, seven undergraduate students, nine technologists and 32 technicians. The Foundation encourages the training of its employees and there is an incentive for post-graduate studies, but not as strong as at Embrapa. As a non-governmental entity, the Foundation offers little "job stability" and thus does not create incentives for a long career inside the organization. On the other hand, the search

for fast solutions and developments technologies means that employees face fewer rules and less bureaucracy than in Embrapa.

The specialized technical staff provides expertise for the preparation of projects and partnerships, and partnerships with both private and public-sector entities provide a valuable exchange of experiences, generating further knowledge for both parties. Projects and procedures are well-known and effectively pursued by both parties, with wide-ranging discussions regarding corrections and adjustments and new paths to be taken.

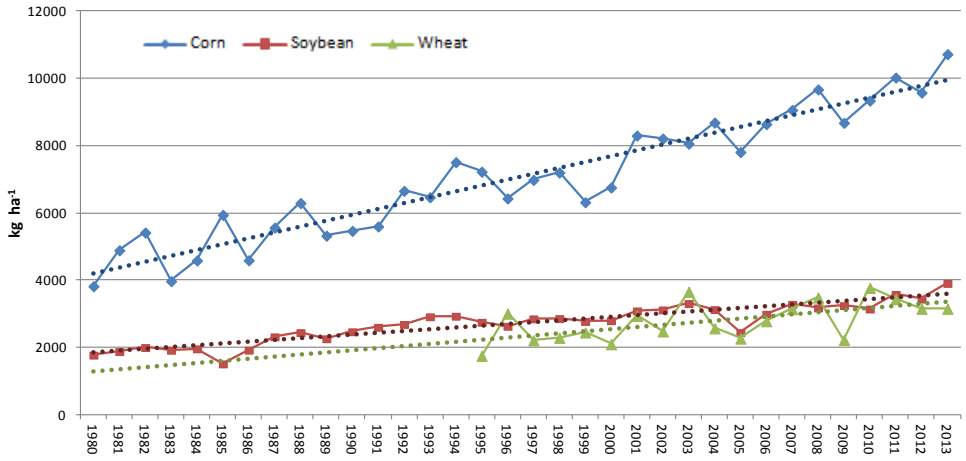
As observed, it appears that, while the development of all three kinds of capabilities—technical, organizational and political—is needed to promote technological innovation, the Foundation was most able to develop its organizational capacity, particularly with regard to effective coordination in accessing scientific and technical expertise to respond to demands for innovation. In this sense, it seems that the Foundation's organizational capabilities are enhanced by its flexibility relative to its decision-making processes, which results in the efficient partnerships necessary for innovation and dissemination.

3.3.4 Analysis of the Results of the Policies and Identification of Their Effects

The greatest evidence of the relevance of the organizational variable for building in-house capability and the success of outsourcing some technical/scientific research has been the productivity gains achieved in the region where the Foundation operates, as shown in Figure 11.

In this case, it seems that organizational capabilities are enhanced by the flexibility of ABC Foundation in its decision-making processes, resulting in efficient and effective partnerships that provide the capabilities necessary for innovation and its dissemination.

Figure 11. Productivity of ABC Foundation-Sponsored Producer Cooperatives: Corn, Soybeans, and Wheat, kg/ha



Source: ABC Foundation.

- *Capabilities and Counterfactuals*

What would have happened if the ABC Foundation had not intervened in the region? This question is difficult to answer because in recent years Brazilian agriculture has generally displayed huge gains in productivity and in the production of important technological advances.

The region encompassed by the ABC Foundation, however, presents relevant results when comparing the average productivity of major crops produced by its members in the years preceding the case with the average from recent years. Also noteworthy are the results obtained from the productivity of these same products with the national average and the average of the states of Sao Paulo and Parana, which have similar production structures. For an international comparison, Table 6 shows that, after the case, the productivity of ABC Foundation members approached that of the most important producers, the United States and its main producing regions, the states of Iowa and Illinois. Moreover, in the last harvest included in the table the productivity of ABC Foundation members even surpassed those U.S. regions, further highlighting their technological advances.

Table 6. Productivity of ABC Foundation-Sponsored Producer Cooperatives: Corn, Soybeans, and Wheat, kg/ha

Corn	Productivity (bu/a-1)		
	1980-1995	1995-2013	Last Harvest
ABC Foundation	**89**	**133**	**171**
Brazil	32	56	82
São Paulo	44	75	97
Paraná	42	88	141
USA	111	141	152
Iowa	114	155	172
Illinois	119	151	157
Soybean	Productivity (bu/a-1)		
	1980-1995	1995-2013	Last Harvest
ABC Foundation	**34**	**46**	**58**
Brazil	27	38	43
São Paulo	29	38	48
Paraná	31	41	49
USA	32	40	43
Iowa	39	47	51
Illinois	37	45	51
Wheat	Productivity (bu/a-1)		
	1980-1995	1995-2013	Last Harvest
ABC Foundation	**27**	**42**	**47**
Brazil	19	29	40
São Paulo	20	30	39
Paraná	20	30	43
USA	36	41	46
Iowa	30	41	53
Illinois	43	55	63

Source: FAS-USDA, CONAB, ABC Foundation.

Another factor that contributed to the development of the region was the policy of technical assistance given to producers, with a focus on diversification of production. This proposal was presented at the 10th International Meeting on Integration of Agriculture, held in March 1997. In this meeting ABC Foundation led the way in encouraging the integration of grain production and livestock activities. Moreover, with the aid of Embrapa and its development of corn seeds adapted to winter conditions, producers could rely on other crops besides wheat for that period.

Table 7 shows the growth of productivity of corn production throughout Brazil and in the states of Parana and Sao Paulo. It is interesting to observe how winter corn (second harvest) begins to show significant increases in productivity through the use of technology.

Table 7. Corn: Average Productivity in Brazil and in Sao Paulo and Parana States, First and Second harvest (bu/a-1).

Productivity	**First Harvest**			**Second Harvest**		
(bu/a-1)	1990-1995	1996-2000	2000-13	1990-95	1996-2000	2000-13
Brazil	37	42	61	26	31	56
São Paulo	48	57	82	33	31	49
Paraná	48	59	99	29	32	57

Source: CONAB (2014).

Milk provides another notable example. The municipality of Castro is the most productive in Brazil, reaching production of 210 million liters in 2011. While the average productivity of cows in Brazil is 2,400 liters/cow/year, producers in Castro reach an average of 10,900 liters/cow/year.[15] Furthermore, the region's milk production is considered a benchmark for all of Brazil, and Normative Instruction 51 (subsequently modified by IN 62) was created based on the quality control practices adopted for the region by the Cooperative Castrolandia.

It is worth noting that in 2011 the region of Ponta Grossa presented the second-highest Gross Value of Rural Production Rural in Parana. Within the region the municipality of Castro stood out, second only to Toledo, a city that houses important agribusiness companies.[16]

With regard to the growth of agricultural income, the cities that are in the Foundation's sphere of influence presented significant growth, largely due to the growth of the Brazilian economy, particularly post-Real Plan. Although this nationwide economic boom accounts for much of the income growth results, the Foundation must receive some credit, as Parana state as a whole grew at a rate well below that of the municipalities served by the Foundation.

[15] http://www.agricultura.pr.gov.br/arquivos/File/deral/Prognosticos/leite_2012_13.pdf.
[16] http://www.agricultura.pr.gov.br/arquivos/File/deral/vbp_2011.pdf.

Table 8. Agriculture Income (Consumer Price Index Adjusted, 1995 = 100), 1997 and 2012

Municipalities	1997 (Thousand Reais)	2012 (Thousand Reais)	Growth Rate (%)
Carambeí – PR	23,921.14	53,229.46	122.5
Castro – PR	61,790.80	207,362.68	235.6
Ponta Grossa – PR	47,383.17	107,768.26	127.4
Tibagi – PR	43,747.72	155,093.62	254.5
Arapoti – PR	16,914.02	47,213.78	179.1
Brazil	31,405,303.94	70,460,642.92	124.4
Paraná	41,52,511.87	8,692,398.95	109.3

Source: Instituto Brasileiro de Geografia e Estatística.

Finally, we present data from the Human Development Index (HDI). Likewise, it would be unwise to attribute such results to the ABC Foundation. On the other hand, positive results lead us to conclude that the region was able to harness efficiently the effects of the Brazilian government's policies during this period.

Table 9. Human Development Index (HDI)

	1991	2000	2010	(2010/1991) %
Brazil	0.493	0.65	0.69	39.96%
State				
Paraná	0.507	0.65	0.75	47.73%
Foundation Region				
Ponta Grossa	0.548	0.68	0.76	39.23%
Carambeí	0.455	0.65	0.73	60.00%
Castro	0.456	0.61	0.70	54.17%
Tibagi	0.371	0.52	0.66	78.98%
Arapoti	0.465	0.63	0.72	55.48%

Source: United Nations Development Programme.

- *Measuring Agency Capabilities*

Table 10 summarizes the assessment of ABC Foundation's capabilities, following the classification presented by Cornick (2013).

Table 10. ABC Foundation's Capabilities

CAPABILITY		Assessment of capabilities
Type of Capability	**Desirable outcomes**	
Technical	Scientific/technocratic expertise	The FABC has a limited number of in-house researchers. The search partnership aims to increase its capacity for innovation.
	Bureaucratic efficiency	With regard to the technical scope of bureaucratic efficiency, there is no evidence that the structure encourages a significant increase in the technical area.
Organizational	Public-public coordination	This case involves collective-public coordination. Despite the difficulties experienced, the FABC has partnerships with universities and Embrapa.
	Public-private coordination	This case involves collective-private coordination. The FABC has many partnerships with the private sector. The FABC has no difficulty in forming partnerships and displays a flexible structure.
	Experimentation and learning	The FABC proved capable of changing its organizational structure to foster partnerships.
Political	Credibility	Regionally, the FABC has very strong credibility.
	Creation of support groups	The FABC is locally very influential in the rural sector. It is seen as a benchmark.
	Protection against capture (public and private)	Depends on the support of private partnerships, as the administrative structure could be captured by partners.

Source: Based on data collected at interviews and on publicly available information.

As we have seen, ABC Foundation is strong on coordinating with the private sector and has concluded several agreements with private firms. This feature is partially explained by the fact that the Foundation is made up of cooperatives and thus has always been close to the private sector. Politically, the Foundation enjoys strong credibility among cooperative members and in the region where it is located. There are commissions to follow up on the studies in which it is involved (support groups), and the Foundation is focused on providing support to cooperatives.

The fact that the ABC Foundation is made up of cooperatives and partners with mostly private firms makes it less susceptible to public (governmental) intervention. However, private intervention may occur, although the supervision of cooperative members makes it difficult for the interests of one particular agent to be favored over others.

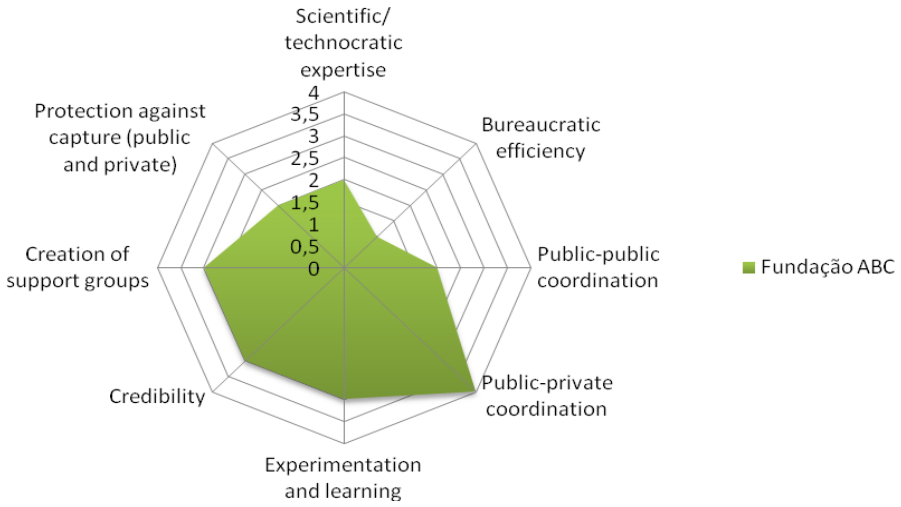
On the other hand, given its limited scientific and technological expertise, the Foundation needs the complementary capabilities that it finds in the market. In particular, partner organizations have more expertise than the Foundation in efficiently developing technology. The ABC Foundation's structure thus compensates for its limitations in some areas with its bureaucratic efficiency, since it is flexible in its operations.

The ABC Foundation does not, however, enter into many partnerships with public entities other than its agreements with Embrapa and universities. Although partnerships with the private sector are more effective and efficient, there is a risk of capture by these companies, since they clearly have an explicit interest in selling the fruits of research to producers, which is not the case with public organizations.

Finally, the ABC Foundation takes advantage of the synergy developed in its partnerships to create a virtuous cycle of results and credibility. In fact, the Foundation does not need to invest in the creation of political ability, since it ensures positive overall results that lead to reputational gains. However, the dependence of technological development on the private sector, which has clear interests in developing short-term technology to sell to producers, can lead to negative effects. First, this relationship can create an economic dependence, since producers becomes dependent on these inputs; second, and on the other, such can have negative effects on the environment, as intensive use of land, leading to the need for greater use of chemicals.

The measurement of ABC Foundation's capabilities is illustrated in Figure 10, following the methodology presented in Section 2.

Figure 12. ABC Foundation's Capabilities



Source: Authors' compilation.

3.3.5 Final Analysis and Comments: The Case's Contributions

The case of the ABC Foundation illustrates the building of capabilities for productive development in a collective organization that operates under private control. The history of the ABC Foundation showed that the cultural ties of its members to Dutch immigration played an important role in allowing the creation of an organization with strong horizontal ties. In the absence of the government, the cooperation of the associates enabled the orchestration of partnerships for the adoption of development policies that generated externalities in the region around it.

Schematically, two types of partnerships were observed:

1. ABC Foundation and private sector (organizational capabilities aligned with political technique): the ABC Foundation's partnership with multinational agrochemical and seed companies is largely made possible by the latter's need to make the most effective use of the commercial potential of the technological innovations produced. In other words, they require cooperation with local production facilities to ensure their own competitive position. It is worth noting

that the strategies of multinational subsidiaries in developing economies, in order to respond to a highly competitive environment, are characterized by a stage in which the creation of specialized resources is required to compete. This strategy is best facilitated by association with local capabilities.[17] The arrangement adopted aligns the incentives of the partners, since the investing companies receive monetary compensation through the sales of their products and the ABC Foundation increases its credibility through its association with positive results in terms of productivity of its members and the region as a whole (external action).

2. ABC Foundation and public companies (organizational capabilities aligned with policy + technical). In this case, the public sector orchestrates the partnership. For the ABC Foundation, public partnerships, although operating with much greater delays than private partnerships, can increase the Foundation's credibility, given the reputation of public institutions such as Embrapa and universities. By allowing public partners to use its experimental farms, the Foundation fosters the development of scientific research and production, allying its image in the research area with that of Embrapa and universities. The success of Embrapa's dissemination of winter corn seed is a good example of this process.

In this sense, it is observed that the ABC Foundation's main capability is its organizational structure, which allows it to access complementary expertise in a hybrid arrangement. This type of governance creates routines and an organizational learning effect, fostering a space to explore the technical capabilities of its partners.

The case offers two important lessons: i) it is possible to "build institutional capabilities for productive development policies" through an organization of collective interest, and ii) it is possible that one or even two of the three particular groups of capabilities (technical, organizational, and political) needed to promote technological innovation can be neglected (not developed in-house), indicating that competence can be developed from hybrid relations. What is crucial is that the promoter agency create capabilities (and a governance structure) that enable it to access complementary capabilities externally.

[17] See Pearce (1989).

4. Comparative Analysis

The three cases studies presented in the previous section allow for a comparative analysis that sheds light on the propositions raised in Section 2. This section explores evidence provided by the three cases to discuss those propositions and to address to some degree the broader question of how to build capabilities and how capabilities map to public policy.

All three cases provide evidence regarding the use of hybrid forms, such as partnerships, to assemble capabilities that are allocated into different organizations. Embrapa, with outstanding technological capability and control of agricultural varieties adapted to the tropical, established long-term contracts with private companies to disseminate innovation of new varieties, particularly those that incorporated genetic engineering, a technology in which multinational company Monsanto had greater expertise. ABC Foundation also resorted to partnerships to attract financial resources and technological expertise. This case additionally provides a complementary view of Embrapa's partnerships, since ABC Foundation had also established some collaboration with the state research company. Likewise, Embrapii/Finep is a case that is heavily based on partnerships. Embrapii was designed to trigger tripartite collaboration among research institutes, companies and Embrapii itself, based on the diagnostic that complementary capabilities required for innovation had been developed in these different types of organizations: firms and research institutes.

The Embrapa case deserves further discussion. When Embrapa began its collaboration with Monsanto and other private groups, it had a market share of 70 percent of soybean varieties, and in 2014 its market share was lower than 10 percent. Several factors may have contributed to this huge drop in Embrapa's market share, such as the increased relevance of genetically modified varieties whose technology was dominated by private companies such as Monsanto and Syngenta. Still one can argue that Embrapa's partnerships accelerated the innovation rate by those private companies, which resulted in a lower market share for its own varieties after several years of partnership. Once this effect is acknowledged, it is fair to ask a normative question: was this a signal of successful policy or of a failure?

To assess the degree of success of Embrapa's policies, it is necessary to re-state its mission: the technological development of Brazilian agriculture. As a consequence, market share in soybean varieties is not an appropriate proxy for Embrapa's achievements in the technological development of soybean production. On the contrary, Embrapa is not a direct competitor of

private companies, since it does not intend to attract consumers as an instrument to maximize profit or market share. It intends to provide consumers (farmers) the most efficient techniques, but it is irrelevant if these efficient techniques are supplied by Embrapa or by other organizations such as multinational companies. The Embrapa's germoplasm of soybean varieties adapted to the tropical zone (in the cerrado and rain forest biomes) was crucial to the success of Brazilian agriculture, both for the direct contribution of Embrapa's varieties and its indirect contribution by means of private companies' innovations, accelerated by partnerships with Embrapa.

This current outcome was indeed a conscious policy, consistent with Embrapa's role of performing R&D investment of public interest in segments with little or no private sector participation. Indeed, Embrapa's strategic planning has concentrated innovative efforts in breakthrough sectors, such as nanotechnology for agriculture, and in areas less attractive for private companies, such as environmental sustainability and technology for small family farms.

The Embrapii/Finep case also illustrates the importance of hybrid forms for assembling complementary capabilities. The model of a PDA oriented to provide financial support to innovation projects derives from the diagnostic that essential technological capabilities are located within companies. As a consequence, the success of technological policy for the industry requires the ability to put those capabilities into action. Before the creation of Embrapii, Finep faced some institutional constraints in providing financial support directly to private companies and. Moreover, it did not possess internally the capability of selecting the most promising private projects so as to allocate its resources efficiently.

The creation of Embrapii, incubated within Finep, was accompanied by a tripartite model that induces partnership with research institutes, which possess general scientific knowledge, and with firms, which possess specific knowledge about production. The innovation project, financed by Embrapii, is a complex hybrid form that connects three essential parts. Embrapii itself provides funding and control; research institutes, such as IPT, provide their scientific expertise, scientists and laboratories; and firms provide production and market knowledge. The contract was designed to provide the appropriate incentives for researchers and companies to identify suitable matches between potentially marketable innovations and the research institute resources to develop them, a pre-condition for receiving funding. It is also noteworthy that the contract involves the Industry National Association (CNI), which enforces the contract and provides the political capability essential to legitimize Embrapii and its technological policy.

The comparison between Finep/Embrapii and Embrapa also sheds light on the second hypothesis raised in Section 2. Whereas the first PDA aims to foster innovation in industry, the second targets agriculture. Although one could claim that there is substantial heterogeneity within each of these sectors, they are quite different with regard to the allocation of technological capabilities between PDAs and productive actors (firms or farms). In order to innovate in industrial sectors, it is necessary to rely on tacit knowledge that is built and accumulated within firms (Dosi, 1988). In contrast, expertise for innovation in agriculture—in genetics, mechanization, defensives, and fertilizers—is rarely present within farms. Experimental farms are particularly important as a later stage of R&D in order to test technologies before launching them in the market, but experimental farms differ considerably from regular farms, which are not a common location for innovation. As a consequence, it is feasible to accumulate technological knowledge in a PDA oriented to technological innovation in agriculture, as was the case of Embrapa, whose main capability is an outstanding group of highly qualified researchers.

A PDA oriented to technological innovation in industrial sectors could not resort to the same strategy. It would be unfeasible to accumulate all required technological knowledge for innovation in industrial sectors within the same PDA, due to the fact that industrial knowledge is by and large tacit and is accumulated by experience in production. This is what explains the fate of research institutes dedicated to industrial innovation, such as IPT, which comprises a large and competent group of researchers but is not able to deliver so many marketable innovations. This feature explains Finep/Emprapii's decision to act as a coordinator of contracts between firms and research institutes, as well as a provider of financial support. Different from Embrapa, Embrapii does not assume responsibility for acquiring technological capabilities, but rather acquiring bureaucratic and public-private coordination capabilities. The need to create conditions for the acquisition of these capabilities helps to explain the creation of Embrapii as a new organization, formally separated from Finep. This issue leads us to the discussion of the third hypothesis raised in Section 2.

Some organization choices are difficult to change and, at the same time, may have profound implications for incentives and control mechanisms within the organization. As a consequence, these organizational choices are important determinants of intensity and the scope of capability acquisition. All three case studies provide evidence to corroborate this proposition.

Embrapa is a state company whose incentive structure is modeled as an internal labor market, similar to other state companies, such as Petrobras. It has its own stable career path, with impersonal hiring rules, normally at the beginning of employees' careers, negligible labor turnover, and incentives based on administrative control mechanisms similar to what is seen in universities. As a consequence, younger employees have strong incentives to acquire specific human capital whose return can be appropriated throughout their career in Embrapa. This was quite clear in the early years of Embrapa, when its researchers had not yet received formal technical training. An intense training program followed, and during this period the majority of Embrapa's researchers were sent to the United States to complete their PhDs in areas such as biology, agronomics and others related to the agency's research. Virtually all these researchers returned to Embrapa and continued to work for the organization until retirement.

This policy has always been maintained, and it is the key variable that explains the outstanding technological capability that Embrapa has acquired. More recently, with the sharp increase in the supply of PhDs in Brazil, it is common to hire new researchers who have already received technical training, possessing PhDs and some academic experience. Curiously, interviews revealed that hiring researchers with better qualifications diverts focus from Embrapa's interests. As the youngest researchers begin their career carrying the culture and values from their former experience in Universities, as PhD students and research assistants, they do not fit in with Embrapa's values and culture as smoothly as their predecessors. This feature of Embrapa's new researchers has some negative implications for the effectiveness of partnerships with private companies, as the ABC Foundation case reveals. Guided by incentives that are typical of universities, the reporting of research results follows the timeline of publication in specialized journals, which takes far longer than private companies would prefer.

The same organizational mechanisms that safeguard the long term-employment relationship create adverse effects on the acquisition of other capabilities. The career of a public servant in Embrapa is quite secure and reliable, which reduces incentives related to contract severance. Moreover, as a state company Embrapa is subject to very strict control mechanisms under Law 8.666, which disciplines government procurement and expenditures in general. This governance structure, undoubtedly less flexible than what is found in private companies, makes Embrapa less sensitive to short-term market opportunities and also increases the fixed costs

associated with public-private coordination. For these reasons, Embrapa is less equipped with capabilities for public-private coordination.

One could argue that large private companies such as Monsanto would face similar difficulties in establishing partnerships. Indeed, when Embrapa's administrative control mechanisms required some minor revisions in the contract with Monsanto, those changes had to be submitted to the headquarters of the multinational company, evidence that a large private company also has to rely on administrative control mechanisms. However, the contractual model initially proposed by Monsanto was standard for private companies, as is the case of ABC Foundation, which did not report any difficulty in adapting itself to the terms of the standard contract. In short, the case studies suggest that it is relatively more costly to establish partnerships between Embrapa and private companies than between these companies and other private organizations.

Differently from Embrapa, ABC Foundation has a quite flexible governance structure and uses this feature to take advantage of short-term market opportunities. On the other hand, the PDA does not have a secure and stable budget, which requires it to present short-term achievements to its stakeholders in order to ensure the financial supports it needs. Indeed, several ABC Foundation partnerships serve as a source of financial resources from private companies that seek access to the large base of farmers that the Foundation represents. Partnerships of this sort do not necessarily combine complementary technological resources, and, as a consequence, they are not primarily oriented to leveraging the Foundation's ability to innovate. Instead, their role is to provide financial resources that allow for the continuity of Foundation activities. A different type of partnership is those established with universities and research institutes, and with some private companies eager to have access to the experimentation fields from the ABC Foundation. Those partnerships typically combine the Foundation's capability to perform field experiments with the capability to develop advanced technological inputs for agriculture, in the case of private companies and research institutes.

Inasmuch as the ABC Foundation cannot rely on a long-term budget, it does not provide employees and researchers the assurance of a long-term relationship. The consequences are twofold. On the one hand, they do not have incentives to acquire highly specific knowledge as observed at Embrapa, and, hence, the PDA has not developed noteworthy technological

capabilities. On the other hand, employees have stronger incentives to seize market opportunities, notably those that yield short-term returns.

The acknowledgement that organizational choices constrain the development of different types of capabilities is the basis for the creation of Embrapii, which delivers policies that Finep could not. As mentioned above, to trigger technological innovation in industry, Finep has to combine complementary technological resources, such as expertise and specific knowledge that are located in firms and in research institutes. Although the creation of sector funds has provided financial resources for Finep to allocate to promising projects, as a state company the PDA had to comply with several restrictions that limited its ability to support directly innovation projects undertaken by private companies.

The tripartite model, discussed in the beginning of this section, provides an interesting mechanism for detecting and fostering suitable matches of firms and research institutes in joint research projects. However, the tripartite model alone is not enough to explain the creation of Embrapii, since it could have been implemented by Finep itself, as all the pilot projects indeed were. For more effective public-private coordination, Finep understood that it was necessary to assign the responsibility of the tripartite model to an organization free from the public sector's administrative control mechanisms. The solution was the creation of a social organization governed by private law and quite flexible in articulating research institutes and firms in joint projects. Embrapii has thus built in a short time the capability for public-private coordination required to trigger innovation in industrial firms.

The evidence presented here suggests that the development of capabilities in PDAs is subject to what Williamson (1996) called the "impossibility of selective intervention" as well as hybrid modes of organization able to provide strategic capabilities, as the modern RBV argues. Organizational choices that implement incentives and control mechanism within PDAs are conducive to the development and accumulation of specific types of capabilities, but at the cost of neglecting the development of others. This intrinsic trade-off has normative implications for public policy that are further developed in the final remarks of this study.

5. Conclusions

This study investigated the building of capabilities within productive development agencies (PDAs). By means of a comparative analysis of three case studies of Brazilian PDAs—Embrapa,

Finep/Embrapii, and ABC Foundation—this paper has aimed to address how PDAs' capabilities evolve and how they relate to the efficacy of their intended public policy. All three PDAs intend to deliver policies oriented to technological innovation and technological catching up, allowing for the control of this type of public policy, which arguably has an effect on the required capabilities and how they relate to the success of public policy. Moreover, the analyses relied on pseudo-counterfactuals in order to try to identify the effect of observed facts on building capabilities and their effect on the quality of public policy. One can argue that case study analysis does not have external validity for a general corroboration of the findings presented herein. Still, we submit that the in-depth analysis of the three PDAs shed some light on the complex questions of how capabilities evolve and affect policy quality.

The comparative analysis of the three cases studies focused on the variability of PDAs' organizational features and of the recipient of the public policy (agriculture versus industry). The main findings are the following: i) when different organizations possess complementary capabilities, hybrid forms such as partnerships can enhance the efficacy of the intended public policy; ii) the appropriate design of the PDA (e.g., to build internally technological expertise or to establish partnerships with other organizations) depends on the features of the sector that is the target of the public policy; and iii) organizational choices are subject to the "impossibility of selective intervention," that is to say that they are conducive to the acquisition and development of specific types of capabilities, but at the cost of neglecting the development of others.

These findings, although in need of further scrutiny, have clear policy implications. Inasmuch as sticky organizational features may drive which capabilities a PDA tends to acquire, it may be advisable to assemble a portfolio of PDAs as an instrument to build the required capabilities for an effective public policy. It may also be necessary to develop the capability to articulate PDAs that possess the complementary resources required to deliver public policy. The Finep/Embrapii case is illustrative of this strategy, when the instrumental policy was the creation of a second PDA, with organizational features that allowed the building of capabilities that were unfeasible for the previous PDA.

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Appendix 1. Draft Questionnaire

1) General characteristics of the agency (such as number of employees and researchers, agency's revenues, etc.) and of the analyzed episode.

2) Factors that motivated and led to the episode.

3) Agents involved in the episode (it would be more appropriate to go to the interview already having this information – the answer may be biased).

4) Narrative of the episode (trying to keep the focus on facts and not opinions and impressions).

5) Description of the agencies capabilities with counterfactual: before and after the episode and comparing the agency with the markets' average (or Brazil's average).
For description of the agencies' capabilities, follow the table from the Appendix of the IDB's Call for Research Proposals, as applicable:

Type of Capability	**Desirable outcomes**	**Key factors or elements**
Technical	Scientific/technocratic expertise	- Specialized knowledge for design, implementation and evaluation of the interventions
	Bureaucratic efficiency	- Qualified staff at all levels of the organization
Organizational	Public-public coordination	- Alignment of agencies by: shared and/or similar vision "intervention technology" and/or clear direction by the Principal
	Public-private coordination	- Effective commitment by the PDA - Mutual trust - Credible agenda
	Experimentation and learning	- Allows space to experiment (and fail) and feedback mechanism

Type of Capability	Desirable outcomes	Key factors or elements
		- Willingness to make policy adjustments
Political	Credibility	- Establish a reputation for delivering what is agreed upon (credible commitments)
	Creation of support groups	- Management of degree of "exposure" - Building of broad consensuses on objectives
	Protection against capture (public and private)	- Operational autonomy - Transparent allocation processes - Co-financing of interventions

Source: IDB's Call for Research Proposals: Building Institutional Capabilities for Productive Development Policies, Appendix.

6) Draw attention to complementarities between the necessary capabilities for the development of the policies (how capabilities of one agency interacted with the capabilities of the partner, advantages of combining the capabilities for the development of the project instead of developing all capabilities within one sole agency, etc).

7) Assessment of the policies' results (for example: what is the productivity of a producer linked to ABC Foundation/).

Appendix 2. Interviews and Other Sources

EMBRAPA

1) Geraldo Martha Júnior (Embrapa)
2) Ronaldo Pereira de Andrade (Embrapa)
3) Vitor Hugo de Oliveira (Embrapa)
4) Eduardo Assad (Embrapa)
5) Pedro Antônio Arraes Pereira (ex-president Embrapa)
6) Fabio Ribas Chaddad (Prof. Univ Missouri)

FINEP

1) EMBRAPII and FINEP

Name: Roberto Vermulm

Enterprise: Embrapii and former employee at FINEP

Job title: Director of Operations

Date: May 04, 2014 (in person)

2) EMBRAPII and CNPq

Name: Fátima Sandra Marques Hollanda

Enterprise: Embrapii and former employee at CNPQ

Job title: Director Advisor - Monitoring and Evaluation

Date: 1st interview (by Skype) on May 22, 2014

2nd interview (in person) on June 07, 2014

3) FINEP

Name: William Respondovesk

Enterprise: FINEP

Job title: Manager at Department of Aerospace, Defence and Security (DADS)

Date: May 26, 2014 (Skype).

ABC Foundation

For this case study interviews were conducted with directors and former directors of ABC Foundation, and materials were collected from the Foundation and the interviewed. The interviews took place in person and via telephone. The first interview was held on February 17, 2014 at the headquarters of ABC Foundation, in the city of Castro, State of Parana, with the General Manager of Research, Mr. Eltje Jan Loman Filho. Subsequently other two interviews with the same person were conducted on May 6 and June 9, 2014, both by telephone. Another interview was conducted by telephone with Mr. Richard Borg, president of the FABC in 1995-2000 period, on May 7, 2014.

Appendix 3. FINEP

1. *INSTITUTIONAL FRAMEWORK OF THE SECTOR FUNDS:*

FUND	LEGISLATION
CT-PETRO – Oil and Natural Gas	Law nr. 9.478, from August 06, 1997; Law nr. 11.921 from April 13, 2009; Decree nr.2.455 from January 14,1998; Decree nr. 2.705 from August 03 ,1998; Decree nr. 2.851 from November 30, 1998; Decree nr. 3.318 from December 30, 1999; Decree nr. 3.520, from June 21, 2000.
CT-ENERG – Energy	Law nr. 9.991 from July 24, 2000; Law nr. 10.848 from March 15, 2004; Law nr 12.212 from January 20, 2010; Law nr. 12.111 from December 09, 2009; Decree nr. 3.867from July 16, 2001
CT-TRANSPORTE – Land Transportation	Law nr. 9.992 from July 24, 2000; Decree nr. 4.324 from August 06,2002
CT-HIDRO – Water Resources	Law nr. 9.993 from July 24, 2000; Decree nr. 3.874 from July 19, 2001
CT-ESPACIAL – Space Activities	Law nr. 9.994 from July 24, 2000; Decree nr. 3.915 from September 12,2001
CT-MINERAL – Mineral Resources	Law nr. 9.993 from July 24, 2000; Decree nr. 3.866 from July 16, 2001
FVA – Enterprise-University Integration (Green-Yellow)	Law nr. 10.168 from December 29, 2000; Law nr. 10.332 from December 19, 2001; Decree nr. 4.195 from April 11, 2002; Ordinance nº 173 from April 23, 2004.
CT-AMAZÔNIA – Amazônia Region	Law nr. 8.387 from December 30, 1991. Law nr. 10.176, from January 11, 2001; Decree nr. 4.401 from October 01, 2002, repelead by Decree nr. 6.008 from December 29, 2006; Law nr. 11.077 December 30, 2004.
CT-INFRA – Infrastructure of Research	Law nr. 10.197 from February 14, 2001; Decree nr. 3.807 from April 26, 2001
CT-SAÚDE – Health	Law nr. 10.332 from December 19, 2001; Decree nr. 4.143 from February 25, 2002
CT-BIOTEC – Biotechnology	Law nr. 10.332 from December 19, 2001;Decree nr. 4154 from March 07, 2002

FUND	LEGISLATION
CT-AERO – Aeronautical	Law nr. 10.332 from December 19, 2001;Decree nr. 4.179 from April 02, 2002
CT-AGRO – Agribusiness	Law nr. 10.332 from December 19, 2001;Decree nr. 4.157 from March 12, 2002
CT-AQUAVIÁRIO – Waterways and Shipping	Law nr. 10.893 from July 13, 2004; Decree nr. 5.252 from October 22, 2004
CT-INFO – Information Technology (IT)	Law nr. 10.176 from January 11, 2001; Law nr 10.644 from April 22, 2003; Law nr. 11.077 from December 30, 2003; Supplementary law nr 11.452 from February 27, 2007; Decree nr.5.906 from September 26, 2004; Decree nr. 6.008 from December 29, 2006; Decree nr. 6.405 from March 19, 2008; Decreee nr. 7.010 from November 16, 2009; Ordinance MCT nº 97 from Febrruary 27. 2007; Interministerial Ordinance MCT/MDIC/MF 148 from March 19, 2007; Ordinance MCT 178 from March 23, 2007

Source: FINEP Management Report, 2012.

2. *FINEP's GOVERNANCE STRUCTURE*

ADMINISTRATIVE COUNCIL

Pedro Wongtschowski (Chairman): Chemical Engineer, with MSc and PhD from Escola Politecnica - Universidade de Sao Paulo. He has served as an officer of Ultrapar since 1985, becoming President and CEO from January 2007 to December 2012 and currently serves on the Board of Directors.

Álvaro Toubes Prata

Caio Mário Bueno Silva:

Carlos Edilson de Almeida Maneschy

Carlos Eduardo Calmanovici

Cláudio Figueiredo Coelho Leal

Glauco Arbix

Horácio Lafer Piva

Jorge Luis Nicolas Audy

Luiz Eduardo Barreto Filho

Marco Antônio de Oliveira

Nelson Fujimoto

Pedro Luiz Barreiros Passos

Rafael Esmeraldo Lucchesi Ramacciotti

Robson Braga de Andrade

BOARD OF DIRECTORS

João Fernando Gomes de Oliveira: Chief Executive Officer

Roberto Vermulm: Director of Operations

José Luis Gordon: Director of Planning and Management

Appendix 4.Evaluation of PDAs' Capabilities

PDA	Type of Capability	Desirable outcomes	Responsible Author	Others - Mean	Weighted Mean	Capability Mean
EMBRAPA	Technical	Scientific/technocratic expertise	4	4.00	**4.00**	**2.80**
		Bureaucratic efficiency	2	1.00	**1.60**	
	Organizational	Public-public coordination	3	3.00	**3.00**	**2.33**
		Public-private coordination	1	3.00	**1.80**	
		Experimentation and learning	1	4.00	**2.20**	
	Political	Credibility	4	4.00	**4.00**	**2.67**
		Creation of support groups	1	1.00	**1.00**	
		Protection against capture (public and private)	3	3.00	**3.00**	
FINEP	Technical	Scientific/technocratic expertise	1	1.00	**1.00**	**2.00**
		Bureaucratic efficiency	3	3.00	**3.00**	
	Organizational	Public-public coordination	2	3.00	**2.40**	**3.27**
		Public-private coordination	4	4.00	**4.00**	
		Experimentation and learning	3	4.00	**3.40**	
	Political	Credibility	4	2.00	**3.20**	**3.20**
		Creation of support groups	3	4.00	**3.40**	
		Protection against capture (public and private)	3	3.00	**3.00**	

PDA	Type of Capability	Desirable outcomes	Responsible Author	Others - Mean	Weighted Mean	Capability Mean
FUNDAÇÃO ABC	Technical	Scientific/technocratic expertise	3	2.00	**2.60**	**3.10**
		Bureaucratic efficiency	4	3.00	**3.60**	
	Organizational	Public-public coordination	2	1.50	**1.80**	**2.93**
		Public-private coordination	4	3.50	**3.80**	
		Experimentation and learning	3	3.50	**3.20**	
	Political	Credibility	4	2.50	**3.40**	**3.33**
		Creation of support groups	4	2.00	**3.20**	
		Protection against capture (public and private)	4	2.50	**3.40**	