Reducing orientation and transaction barriers in Research-Industry-linkages: study of the Brazilian-Industrial Innovation-Agency

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Abstract

Dynamic and productive linkages between research organizations and industry are actively spurred in advanced nations. Conversely, Latin American countries face significant challenges fostering research-industry interactions. Solid models of research-industry cooperation are of particular interest of emerging economies such as Brazil**,** which could take advantage of its position as latecomer and grasp opportunities for policy implications. The goal of this article is to present a comprehensive study of the Brazilian Agency for Industrial Research and Innovation - EMBRAPII as an entity focused on addressing barriers to cooperation between research organizations (ROs) and companies. The study is based on EMBRAPII's initial phase carried out in 2012-2016. A total of 63 projects supported by EMBRAPII involving three ROs and 44 companies were inquired employing four sources of primary data: two web questionnaires applied to project leaders in ROs and in companies; interviews carried out with principal managers of the recipient ROs, and interviews and technical visits carried out by experts in ROs's project main sites. Findings show evidence that the specificities of the model allow the emergence of conditions for effective paths for research-industry cooperation, overcoming both orientation-related and transaction-related barriers.

Keywords: [STI Policy; Latin America; Brazil; Research-Industry Cooperation, Innovation Instruments]

Introduction

Innovation has progressively become a critical determinant of competitiveness, economic growth and national progress. Understood in its four edges – product, process, marketing and organization innovation – (OECD, 2018), the goal of fostering innovation occupies different roles in the economic development agendas of countries. One of the main issues regarding the practice of innovation and research policies is the significance and effects of interactions between actors involved in innovation systems, mainly Research Organizations - ROs (in this article, ROs is a generic term to identify universities, public laboratories, public and private not-for-profit technological and scientific research organizations in general), companies and governments.

Several reasons justify the importance of getting stronger links between ROs and companies (Cohen, Nelson and Walsh 2002; Etzkowitz 1998). Generally speaking, companies collaborate with ROs in order to access leading edge research knowledge, research infrastructures or research services, to complement in-house capabilities, to identify potential future employees and to take advantages of networking effects (Dietz and Bozeman 2005; Schaeffer, Ruffoni and Puffal 2015). Conversely, ROs and universities collaborate with firms to access industrial capabilities and resources, to commercialize research ideas or test their commercial potential, to develop real world links and build experience or to develop potential career pathways for their students (Caloghirou et al. 2001; Cohen et al. 2002; Etzkowitz 1998; Fischer et al., 2017).

Although common requirements do exist for the promotion of RO-industry linkages, specificities are always present. It is well known that the degree of maturity and interconnection amongst agents of innovation systems in all levels – national, regional or sectorial – interfere in the effectiveness of policies headed to promote such linkages. This is particularly important to take into account in less developed or emergent countries as conditions fostering or precluding those linkages entail distinctive challenges.

In these countries the mismatch between research —mainly carried at public ROs —and companies is particularly evident (Arza 2010; Dutrénit and Arza 2010; Fernandes et al. 2010; Suzigan et al. 2009 and Vaaland and Ishengoma 2016). As a consequence, the policy design is chiefly important. Actually, it is an art of combining common well-known requirements – as for well-established intellectual property rules, technology transfer offices, financial support, and skilled people to carry out research and technical services – and specific needs of a given context.

This manuscript aims to analyze the effectiveness of a new policy model conceived to foster cooperation between ROs and companies in Brazil. The model of the Brazilian Agency for Industrial Research and Innovation (EMBRAPII) can be understood as an institutional innovation within the national framework of Science, Technology, and Innovation (STI) policy instruments. It was designed to overcome barriers of orientation and transaction normally found in similar contexts (Bruneel, D´Este and Salter 2010).

To accomplish this objective, the manuscript brings the results of an evaluation of outputs and outcomes of EMBRAPII's initial phase carried out in 2012-2016. A total of 63 projects supported by EMBRAPII involving three ROs and 44 companies were evaluated employing three sources of primary data: two web questionnaires applied to project leaders in ROs and in companies; interviews carried out with principal managers of the recipient ROs, and interviews and technical visits carried with project leaders both in ROs and companies made by experts in the projects' areas of knowledge.

Having in perspective some solid and well-known innovation policy instruments and narrowing it down to contextualize the Brazilian experience of EMBRAPII pilot phase, it is expected that this manuscript, based on the methodological approach designed for evaluating that initiative, provides a better understanding of the design, characteristics and potential impact of EMBRAPII not only from the traditional perspective of technology transfer towards the industrial sector, but also the development of complementary competencies within the research organizations and companies (industry and service oriented) in cooperation for research and innovation. Findings show evidences that the specificities of the EMBRAPII's model allow the emergence of conditions for effective paths for research-industry cooperation in Brazil.

Literature Review

Challenges, barriers and obstacles for successful research-industry cooperation

The issue of how to foster linkages between ROs and companies has become a core one in the field of STI policy debate. More intensely, the last 20 years have seen a proliferation of literature addressing the rationale, benefits and hindrances affecting such linkages. This section focuses on the mismatch, obstacles and difficulties in bridging technological and scientific research with industry applications (Bodas, Marques and Silva 2013; Brunneel, D´Este and Salter 2010; Filippetti and Savona 2017; Kaufmann and Tötling 2001; Muscio and Vallanti 2014; Tartari and Breschi 2012), and how different policy and policy instruments have attempted to lower, reduce and overcome such obstacles.

In recent literature different typologies have been proposed to assess limitations experienced in the cooperative relations between research organizations ROs and companies. ROs-Industry linkages, as partnership, have been defined by Hagedoorn, Link and Vonortas (2000) as an innovation-based relationship; a cooperative nexus in which partners involved aim at unraveling innovation outcomes.

Bruneel, D´Este and Salter (2010) sustain that collaboration between industry and a university faces various constraints. They propose examining such limitations in two categories: first, barriers related to differences in the orientation of industry and universities, described as "orientation-related barriers". Secondly, barriers related to the conflicts over intellectual property and dealing with university administration, described as "transaction-related barriers". These barriers may limit the depth and quality of interactions between universities and businesses, with transaction-related barriers being more difficult to address.

Actually, obstacles and barriers are brought by all parties; they can come from the firms, ROs and third parties. Tartari and Breschi (2012) focus on the costs perceived by academics, scientists and researchers. They understand that collaborating with industry constitutes a discretionary behavior for academics, consequently affecting the success or failure of university-industry collaborative relations. As stated by Etzkowitz and Zhou (2008:632) "Transition to another academic format (entrepreneurship) is rarely as smooth process. It is typically accompanied by controversy, acrimony and debate".

This is consistent with the proposed by Muscio and Vallanti (2014) using a scale to consider 16 obstacles arising from the academic/science perspective divided into four categories: conflicts with companies, networking problems conflicts with academic goals, distance between academic research and business needs. In other words, transaction-related and orientation-related barriers may be considered as two complementary categories of barriers influencing partnerships.

Filippetti and Savona (2017) present an interesting discussion from the company´s perspective. Their analysis focuses on firm´s barriers to cooperation with public research institutions, stating an array of deterrents – not very different from those above cited – which vary depending on the sector of the industry. Simachev, Kuzyk and Feygina (2014) enlist common obstacles to cooperative relations between ROs and companies from the perspective of the latter. In the assessment of the latter group, four obstacles standout: lack of clear procedures and bureaucracy in ROs, insufficient orientation at company needs, incongruence of developments´ quality and company needs, and weak orientation of research organizations at costumer needs.

Kaufmann and Tödling (2001) argue that the interaction of firms with scientific and technological research organizations stimulates industry innovativeness as it enables companies to access to a more diversified range of knowledge. A critical element in their approach is the maintenance of a systemic diversity in order to improve the innovative performance of the firms involved.

At this point it becomes relevant to discuss how policy and policy instruments aiming at fostering ROs-industry cooperation in the process of innovation have addressed the aforementioned obstacles. Particularly, this manuscript draws on the conceptual frame proposed by Bruneel, D´Este and Salter (2010) about the limitations of orientation and transaction. These two categories of limitations may be taken as a synthesis of the vast diversity of obstacles discussed in the specialized literature.

Policy and policy instruments aiming at fostering ROs-industry links in the process of innovation

Several authors have devoted considerable efforts to test the traditional Schumpeterian analysis as well as arguing that innovation is a non-linear, but rather a collaborative process that benefits from interactions amongst agents from diverse environments (Borrás and Edquist 2013; Cunningham and Gök 2012; Etzkowitz and Leydesdorff 2000; Kaufman and Tödtling 2001; Wilson 2012).

In this context, public policy may influence the propensity of firms and ROs to cooperate in order to trigger the beneficial results of such interactions. This presents to policy makers a challenging and constant question of what would be the most appropriate approach to promoting ROs-industry collaboration. In other words, the question is what policies and policy instruments would be more effective to deal with the barriers of orientation and transaction mentioned in the previous section.

The design of policy priorities and the selection of policy instruments is a critical decision when aiming at addressing the identified problems. There are no formulas or infallible prescriptions as sustained by Borrás and Edquist (2013: 1515) "strictly speaking each policy instrument used by a government or public agency is unique".

Leydesdorff, Park and Lengyel (2014) proposed a tool to measure the interactive feedbacks or the mutual information within an interaction of three parts – the Triple Helix approach – in order to understand the level of synergy amongst university-industry-government.

Veletanlic and Sá (2019:110) analyzing RO – industry collaboration in Canada make reference to a typical orientation-related barrier: the prioritization made at the level of policy design does not match partners' interests. "Our analysis points to misalignments at the micro and meso levels between the ideas driving the programs and the incentives at play for academic researchers and industry partners, which culminate in the displacement of macro-level policy goals".

Cunningham and Gök (2012) propose a set of general lessons for the design and implementation of research-industry collaborative support policy instruments. They regard long-term vision and stable commitment of government funding as one of the most successful measures. They also remark the importance of clear understanding of the motivations for the partners to participate in the collaborative relationship, which would require the definition of a clear purpose for the intervention in advance.

Characteristics of the participating entities determine the viability of their performance in the partnership, therefore Cunningham and Gök (2012) recommend matching partners with tracked records of collaboration with new partners, which means relating experienced organization with newcomers. In addition, building a sense of belonging to the process through a strong and positive brand and image is likely to increase further networking.

Veletanlic and Sá (2019) point to misalignments of “programmatic ideas” between partners at micro, meso and macro levels. They investigated two research-industry Canadian programs in order to verify how aligned they had been to the real preferences of academia and companies. In other words these authors found evidences that the “programmatic ideas guiding university-industry programs did not reflect the reality of Canadian firms’ limited engagement in R&D” (Veletanlic and Sá, 2019:113). This suggests policies have raised orientation-related barriers. An immediate consequence of these ‘internal’ misalignments is the necessity of employing indicators able to identify concrete cum specific motivations for of involved parties.

Among the instruments used in public policy to overcome challenges and barriers to research-industry cooperation, Borrás and Edquist (2013) present a three-fold typology: regulatory instruments, economic transfers and soft-instruments. Regardless of the choice of instrument, they argue that the design of innovation policy must include clear purposes and objectives, identifying the problems the policy shall address, as they cannot be solved by the research organizations, neither by the firms without the policy intervention. With this in mind, it is clear that the analysis of barriers to the industry-research cooperation and as a consequence, the characteristics and content of the public policy and policy instruments to address such obstacles, differ amongst countries or even localities because of their very specific ecosystems of innovation.

Bodas et al., (2013) and Guimón (2013) sustain that developing countries may face even greater barriers to establish collaboration between academia and industry. Increasing attention has been paid in the scholarly literature to studying the specific characteristics of interaction between research organizations and firms whether in developed (Arvanitis, Kubli and Woerter 2008; Cunningham and Link 2014; Kroll 2016; Sá and Litwin 2011) or in developing countries (Dutrénit and Arza 2010; Fischer, et al. 2017; Suzigan et al. 2009).

Kroll (2016) presented a study of experiences from various developed countries (Germany, United States, United Kingdom, France, Finland and Norway) consisting of initiatives of long-term strategic partnerships for science-industry collaboration. The author aimed at finding common characteristics and lessons despite different country contexts. Kroll (2016) highlighted some critical elements, amongst them it is worth mentioning: the importance of complementary role among the partners in which actors share a joint perception of future challenges and opportunities combined with the willingness to invest (this is precisely one of the pillars of the EMBRAPII´s case that will be discussed further in this manuscript).

Sá and Litwin (2011) examined the case of Canada and the policy instruments employed by the federal government to stimulate university-industry linkages. Key features in the Canadian experience are the diversification of the policy mix over the last 20 years and a marked shift from stimulating short-term interactions to long-range strategic relationships.

Cunningham and Link (2014) examined the process of fostering university-industry research and development collaboration in the European Union Countries, addressing cross-country differences with special attention on the characteristics of the national innovation systems. Structural elements as for regulatory harmonization within countries´ institutions, intellectual property protocols, standardized agreements and templates, are seen as central to facilitate interaction between universities and business.

An illustrative case is what has been experienced in China. According to Teng (2010:298), the need for greater university-enterprise collaboration and research commercialization is hampered by a number of constraints including, among others "the dominance of foreign investments in the critical sectors of manufacturing; lack of effective R&D funding in industry; lack of highly capable scientists who can lead in terms of knowledge frontiers, lack of innovative entrepreneurship; and focus of universities towards teaching thus creating a divergence of objectives between university and industry".

In the past few years China has experienced important shifts in its STI position, particularly in terms of university-industry collaboration. Zhou et al. (2016) and Cheng et al. (2018) have presented a path of increasing collaboration. Although with limited effects over scientific production (Zhou et al., 2016), collaborations have mainly resulted in technology production. Cheng et al. (2018) emphasizes that university-industry collaboration has been driven by industry in a prevalence of problem-oriented projects, reducing potential orientation-related and transaction-related barriers.

Admittedly, the political scenario and the economic development model of each country determine particular challenges in different developing countries.

Radosevic (2011) analyzed the factors behind recurrent policy failure to support science-industry linkages in Central and Easter Europe as well as Commonwealth of Independent States. Transition economies require specific conditions at the micro and medium-level of technology-based competition, both for internal and international markets; however, he argued that policies for science-industry linkages in these countries followed the linear innovation model instead of the interactive innovation model logic present in more advanced countries. The author also supports the importance of policy experimentation based on a thorough understanding of local context instead of “an uncritical application of conventional policy in the context of catching up and laggard economies” (Radosevic 2011:378).

Experiences from Latin American countries in general and Brazil in particular offer additional insights (Arocena and Sutz 2003; Azevedo and Rezende 2015; Dutrénit and Arza 2010; Fischer et al. 2017; Schaeffer, Ruffoni and Puffal 2015). Dutrénit and Arza (2010) provide some evidences that interactions between ROs and industry, although still weak for international standards, have increased since the turn to the new millennium.

Similar findings were discussed by Suzigan et al. (2009); Rapini et al. (2009) and Fernandes et al. (2010) and de Medeiros, Alves and de Jesus (2012). Studying linkages between Public Research Organizations (PRO) and companies in Brazil, Fernandes et al. (2010) found higher mutual benefits when the relations were based on technical services provided by PRO than on internal investments in R&D. According to Fernandes et al. (2010) this is not surprising for "immature National Systems of Innovation".

The Brazilian context of RO-industry collaboration has shown some advances in the past two decades. Fostering the RO-industry linkages is not a new target of public policies in the Brazilian context. The pursuit for more efficient and effective instruments to foster those linkages is a sort of endless search. Salles-Filho (2002; 2003 a,b) has shown that since the 1970's STI policies in that country have been formally oriented by the so-called necessity of closing the gap between knowledge production and knowledge use – whether in industry or agriculture.

Although an explicit intent of policies in the past 40 years to promote research-industry linkages, the analysis of effectiveness of policy instruments is a much more recent endeavor (Silva Neto et al. 2013; Fischer et al. 2017; Garcia et al. 2014; Terra, Cortines and Almeida, 2013; Suzigan et al., 2009). According to these studies, three main assumptions have supported those policies: a) there are both a cultural and a financial barrier to be removed in order to allow a two way flow between parties; b) there is useful knowledge in ROs that is of interest of companies; c) once those barriers are removed companies will naturally be interested in adopting knowledge or allocating resources for joint developments.

To tackle these conditions, policies have been mainly driven by a supply-side perspective: ROs as policy's recipients to assume the endeavor of breaking the barriers and transfer their stock of knowledge. Even the attempts to implement policies focused on the demand-side – offering financial support directly to companies – have been based on a similar rationale: there would be a latent and unsatisfying demand on the companies' side that could be released throughout subsidies. The "theory of change" behind those policies has relied on the assumption that by reducing the cost of money - and related risks – it would naturally motivate companies to be more research and innovation seekers. Recent studies have shown the problem is beyond this rationale.

Various authors (De Negri and Cavalcante 2014; Fernandes et al. 2010; Pacheco et al. 2017; and Rapini et al. 2009) refer to structural conditions in the Brazilian innovation system that need more than financial support, other challenges include: the lack of competition and the focus on the internal market; high level of transaction costs related to the regulatory framework and the complex bureaucratic environment for entrepreneurship.

In point of fact, and with few exceptions, policies have not addressed orientation and transaction related barriers, as proposed by Bruneel, D´Este and Salter (2010).[1] They mostly focus on the cost of money – reducing it throughout different sorts of subsidies – leaving aside other structural factors related to orientation-related and transaction-related barriers.

Study background: the case of EMBRAPII

The Brazilian Agency for Industrial Research and Innovation – EMBRAPII was created in 2011 envisioning research-industry strategic alliances to contribute to innovation in the Brazilian industry. It was conceived under the partnership among the Ministry of Science, Technology, Innovation and Communication, the Ministry of Education, the National Confederation of Industry (CNI) and the Brazilian Innovation Agency (FINEP). EMBRAPII has a novel management model (Azevedo *et al,* 2016; de Castro *et al*, 2017), whose rationale is to influence the relationship and enhance interactions between ROs and companies, sharing costs and risks and aiming technological innovation in pre-competitive stages (EMBRAPII, 2018).

There are two main mechanisms guiding the operation of EMBRAPII. The first is the

[1] One exception is the program PITE (Partnership for Technological Innovation) running since 1995 by the Sao Paulo Research Foundation (FAPESP). This program fosters cooperation between ROs and companies through a matching fund mechanism, usually in a 50/50 base.

accreditation of existing RO's laboratories based on the analysis of a long-term Action Plan and RO's historically developed competences. The accreditation process occurs through competitive Public calls, periodically organized by EMBRAPII. Several calls were placed until the beginning of 2019, resulting in 42 accredited labs. Once the accreditation process is finalized, the labs receive EMBRAPII resources and initiate the accomplishment of Action Plans trough the establishment of partnerships with firms. EMBRAPII non-reimbursable resources represents up to 1/3 of the total value of the project portfolio contracted by each RO; the remaining 2/3 should be negotiated between ROs – financial and non-financial resources – and partner companies – exclusively financial contributions for the latter.

The second mechanism guiding the operation of EMBRAPII is the monitoring of Action Plans and projects execution. From 2013 to June of 2017, EMBRAPII operated a budget of approximately US$ 87 million. As pointed by Goulart (2012), the model was created as a mechanism to articulate efforts of research, development and innovation in a less fragmented and isolated manner than historically done in the country.

Projects from EMBRAPII Pilot Phase, which is the focus of this manuscript, were executed from 2012 to 2016. The Pilot Phase was not based on a Public Call and involved the selection of three ROs: the federal National Institute of Technology (INT), the Sao Paulo state owned Institute for Technological Research (IPT) and the private nonprofit Manufacturing and Technology Integrated Campus (SENAI CIMATEC). In 2015 EMBRAPII hired an evaluation of its Pilot Phase, as a way to understand if the expected results were achieved and to create the inputs for its institutional evaluation model. In the next section, the methodology employed in the evaluation is presented, as well as the main features of Pilot Phase.

Methodology

The evaluation of the EMBRAPII's Pilot Phase was oriented to measure: (i) the outputs and outcomes of the R&D and innovation projects (technological results and its appropriation); as well as (ii) the behavioral changes of involved actors, focusing on governance, prospection of partnerships, negotiation among organizations, project management and project execution. It was based on guidelines of evaluation methodologies suitable for research and innovation policies and programs explored in Edler et al. (2012) and Link and Vonortas (2013).

The methodological approach focused on the additionality of inputs, outputs, and behavioral, tracking down the changes occurred between the baseline T0 and the end of EMBRAPII's Pilot Phase T1. As a Pilot Phase with no similar condition in the National context, and given the short period of project execution (2012-2016), it was not employed a control group. However, it was employed as a proxy of counterfactual a "redundant causality factor" (Salles-Filho et al., 2010; 2011). The redundant causality factor, also called alpha factor (α), is an alternative for approaching causality. Every measurement obtained for a given variable is (re) confirmed using a scale of 0 to 1. The equation below shows how this factor operates in practice.

$$I_{ij} = g_{ij} \mid \Delta(a_{ij}) \mid \alpha_{ij}$$

In which:

g_{ij} represents the sense of the observed variation (-1, 0, 1)

$\Delta(a_{ij})$ represents the measured additionality for a given variable

α_{ij} represents the verifier of redundant causality (0-1)

Sample:

The evaluation focused on the 63 projects successfully executed in the Pilot Phase by the 3 ROs in cooperation with 44 companies.[2] The distribution of projects by ROs was the following: 30 developed by CIMATEC totalizing an amount of U$ 32,2 million; 20 developed by IPT totalizing U$ 15,7 mi; and 13 by INT totalizing U$ 5,8 mi. These amounts included financial resources from EMBRAPII and from companies commonly around a 50/50 base.[3] Regarding the distribution of partner companies by sector (according to the National Classification of Economic Activities - CNAE), the distribution is presented in Table 1 below (some companies were classified in more than one sector):

Table 1: Economic Activity Sector of EMBRAPII partner companies in the Pilot

Sector of Economic Activity	**No.**
Cosmetics	6
Oil and Gas	5
Chemical and petrochemical	3
Drugs and Medicine	3
Medical and dentistry equipment	3
Computer Programs	3
Experimental R&D natural sciences and physics	3
Metallurgy	3
Food Processing	2
Automobiles	2
Auto Parts	2
Textiles	1
Wood Artifacts	1
Intermediates for Plasticizers, Resins and Fibers	1
Elastomers	1
Pesticides	1
Plastic Artifacts	1
Cement	1
Appliances	1
Agricultural Irrigation	1
Aircraft	1
Furniture	1
Minerals	1
Informatics Consulting	1
Office and administrative services	1

Source: the authors

Data collection and data analysis

[2] Some companies had more than one project.
[3] The total cost of projects still include economic-non-financial counterpart from ROs. The total economic cost of a typical EMBRAPII's project is shared on a 1/3 base per partners: company, RO and EMBRAPII.

Data collection was done through four different instruments: (I1) web survey applied to project coordinators in ROs, focusing on project's results and institutional managerial changes (the latter in the context of behavioral additionality); (I2) web survey answered by the responsible for projects in companies, focusing on projects results and on the level of satisfaction from the company perspective; and (I3) semi-structured face-to-face interviews conducted by five experts with project coordinators at ROs and companies, focusing on project results from a technical perspective.[4] (I4) open face-to-face interviews with the board of directors of ROs also were carried out by the team of evaluators, focusing on the institutional and organizational impacts of EMBRAPII's model over the three organizations. A table displaying indicators employed in the evaluation in I1, I2 and I3 is presented in Annex 1.

All but I4 instruments of data collection were pre-tested with a sample of respondents. The application of different types of data collection instruments, orientated to different respondents allowed the collection of diverse data about the outputs, outcomes and behavioral changes and also the consideration of distinct perspectives regarding the selected variables. A summary of these methodological choices and the response rates is presented in table 2 below.

Table 2: Data collection instruments applied, characteristics and responses

Instrument	Application Form	Respondent	No. of projects	No. of responses	Rate of Responses
I1	Online survey	Project Coordinators in the ROs	63	62	98%
I2	Online survey	Project managers in the partner companies	66*	44	67%
I3	Face-to-face semi-structured questionnaires	Experts	25	25	100%
I4	Open interviews with RO's CEOs	Board of directors of ROs	—	3	100%

Source: own elaboration
* One of the 63 projects involved 4 firms instead of just 1; that's why there are 66 project managers in firms.

Data from surveys and questionnaires were analyzed using descriptive and multivariate statistics. In addition, they were compared to each other and with expert's views in order to

[4] Experts visited and interviewed responsible people for a sample of 25 projects after surveys I1 and I2 have been completed.

identify if and to which extent perceptions from the different actors (RO's project coordinators, companies and experts) do converge.

Results, discussion and findings

Results were presented in three blocks. The first block concerns project prospection, negotiation and contract. The second block concerns project management and execution. The third block has a different nature since it is not related to limitations of research-industry cooperation, but with the effectiveness of the arrangements. It comprehends the outputs and outcomes of the projects with emphasis on innovation generation and innovation capacity building.

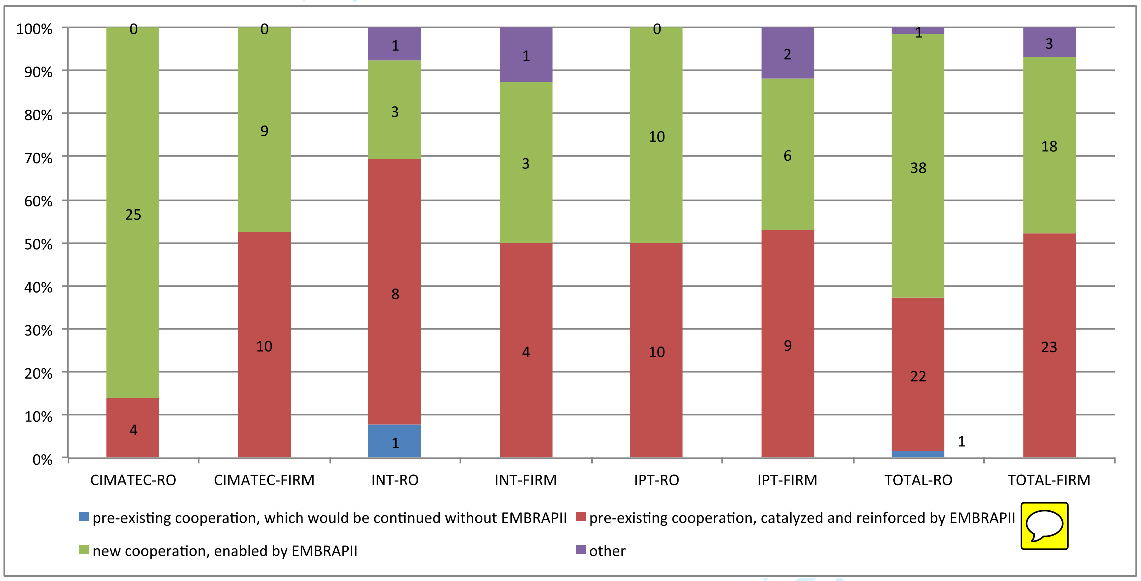
Project prospection, negotiation and contract

How ROs prospect and negotiate cooperation with companies within EMBRAPII framework? As mentioned before, EMBRAPII's model presupposes that accredited ROs should actively look for companies interested in developing joint projects.

Figure 1 indicates that the model was crucial to the establishment of the desired partnerships. From RO's perspective, the most common case was of new cooperation initiatives, enabled by EMBRAPII Pilot Phase; from firm's perspective, the most frequent answer pointed to pre-existing cooperation initiatives, catalyzed and reinforced by EMBRAPII's Pilot Phase.

One possible reason for the different perspectives concerning the evaluation of the same projects is that companies answered the survey based on their relationship with the whole RO, while ROs answered based on the relationship of their particular accredited laboratories with firms. In any case, the derived assumption is that EMBRAPII had an important role in this process. Company's answers about their interests in cooperation strengths this conclusion, since they declared that willingness to cooperate was due to financial resources offered by EMBRAPII in first place and secondly related to human, material and infrastructure resources offered by ROs, in accordance with the literature that investigate the reasons of this kind of cooperation (Dietz and Bozeman 2005; Schaeffer, Ruffoni and Puffal 2015).

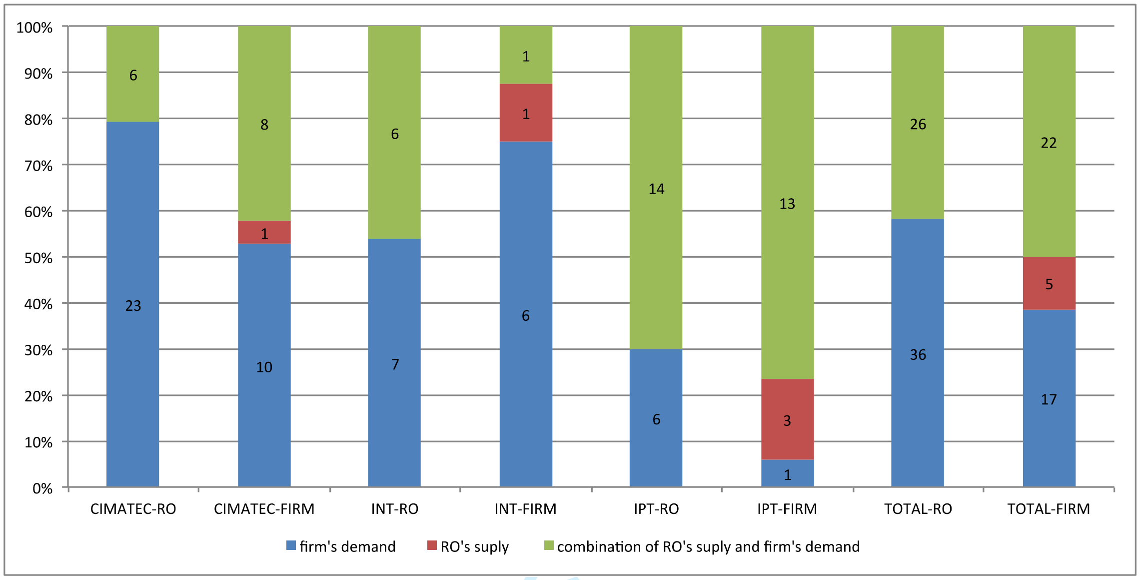
Figure 1: Relations between ROs and firms and the role of EMBRAPII's pilot round (number of answers)



Source: surveys I1 and I2

When inquired about the motivation of cooperation, ROs highlight the firm's demands and secondly the combination of firm's demands and their own interest (Figure 2). Conversely, firms highlight the combination of their demands and RO's supply and secondly their own demands. Once again there are different views about the same phenomenon although firm's demands positively play a central role - by themselves or in combination with RO's competencies. This is a first evidence of how the model contributed to at least partly overcome the linear model approach to innovation policies in developing countries (Dutrénit and Arza 2010) while trying to more effectively consider firm's demands as a starting point to build a joint perception of future challenges and opportunities (Kroll, 2016).

Figure 2: Motivation to cooperate (number of answers)



Source: I1 and I2

As expected, Figures 1 and 2 also shows different perception from the three ROs. In spite of being influenced by EMBRAPII's model, these organizations have particular and historically defined routines and cultures, which influence the way they react to similar incentives.

The time spent for negotiation between ROs and companies was less than 5 months for 73% of the sample, which is a good average considering Brazilian standards for ROs (and mainly for public ROs, normally above 6 months). It also reveals more agility in delivering contracts in comparison with projects supported by public research agencies. For 63% of RO's project coordinators (I1), this time-reduction was totally due to EMBRAPII's model; for 29% of RO's project coordinators it was partially due to EMBRAPII's model.

For 82% of ROs' project coordinators EMBRAPII's model have helped their organizations in creating organizational structures and processes that increased their ability to prospect opportunities and partners, and also to better manage partnerships with companies. This finding is in accordance with Azevedo et al. (2016) that reported, based on interviews with EMBRAPII managers, the development of new capabilities to prospect partnerships, negotiate and carry on complex contracts. A concrete example can be found in de Azevedo and Tukoff-Guimarães (2015) that describes a new method of assessment of economic potential of technological innovation projects and its valuation, developed and applied by IPT since 2012 in the negotiations of commercial exploitation of technologies resulting from EMBRAPII projects.

Finally, when asked about the specific factors of the EMBRAPII's model that facilitated prospection, negotiation and contract of projects from the RO's perspective, respondents emphasized: i. long term flow of financial resources committed to their use; ii. financial counterpart in the same proportion by the other partners (1/3 the RO, 1/3 partner firm, 1/3 EMBRAPII); iii. flexibility for using budget; iv. projects with firms in the intermediary phase of innovation, among other less relevant factors. From firm's perspective, the same factors were pointed, although in somewhat different order of importance. For both actors, intellectual property requirements made prospection, negotiation and contract processes more difficult to be executed.

The previous analysis of how prospection and negotiation processes occurs suggests that particular characteristics of EMBRAPII model contributed to the alignment of RO's and firm's interests. Likewise, the analysis also suggests that the participation in EMBRAPII's Pilot Phase changed the way ROs engage in R&D collaborations with companies.

Project development phase

This section examines how both parties managed projects: ROs and companies. A first point to be investigated is to what extent EMBRAPII's model encouraged the involvement of companies' human resources in project development, including project planning, execution and termination (with validation of results). It is worth noticing that such participation was not mandatory as a condition for the development of the project, although it was desirable as a mean to improve the alignment between the parties during project execution and the potential use of its results.

On this regard, firms reported that 70% of the projects of the sample counted on some sort of involvement. For this group, the average was 0.7 person involved in the execution of the project with partial dedication and also with eventual participation and 0.5 people with exclusive dedication.[5] About additional fundraising for the projects under analysis it only happened in 9 cases: 5 trough tax incentives for R&D, 3 trough Brazilian Innovation Agency (FINEP) and 1 from other federal sources.

Still, positive results were found for project management processes. For 82% of RO's project coordinators, projects employed guidelines or project/portfolio management tools, such as PMBoK. In CIMATEC it happened to all projects; in IPT to 77% of projects; and in INT to 60% of projects. Although previous engagement in best practices for R&D project management, the three organizations invested and generalized the adoption of such practices as a consequence of EMBRAPII's model. Actually, about 85% of ROs project coordinators reported they have changed their usual guidelines to manage and monitor R&D and innovation projects in partnership with companies because of EMBRAPII's model, meaning the model pushed ROs

[5] The perception of ROs for the same issue is below the perception of companies: about 45% of the projects - but with a higher number of people involved – were reported by ROs as having constant personnel from industry taking part on project execution. A possible explanation is the different perception of what "participation" means for both parties. All in all, companies considered they had been involved in the large majority of projects.

towards professionalization of R&D project management.

For more than 81% of companies, projects had performed above or within initial expectations. The influence of EMBRAPII's model in this success rate was rated high to very high. The evidence that 48 out of 62 projects were considered by companies to be continued as new projects or technical services using companies resource –with or without EMBRAPII's support -, reinforces the positive view reported by companies. Once again it is possible to believe that particular characteristics of EMBRAPII model contributed to the construction and maintenance of an adequate relationship between ROs and firms. Additionally, it also changed the way ROs engage in R&D collaborations. In accordance with Sá and Litwin (2011) and Cunningham and Gök (2012), the stability of arrangements and resources along with a long-term perspective of cooperation positively influence the partnership.

The necessary alignment of objectives and targets between companies and ROs foreseen in the EMBRAPII's model, along with a joint administration of projects between parties reveal to be particularly important for the findings, meaning lowering orientation and transaction related barriers.

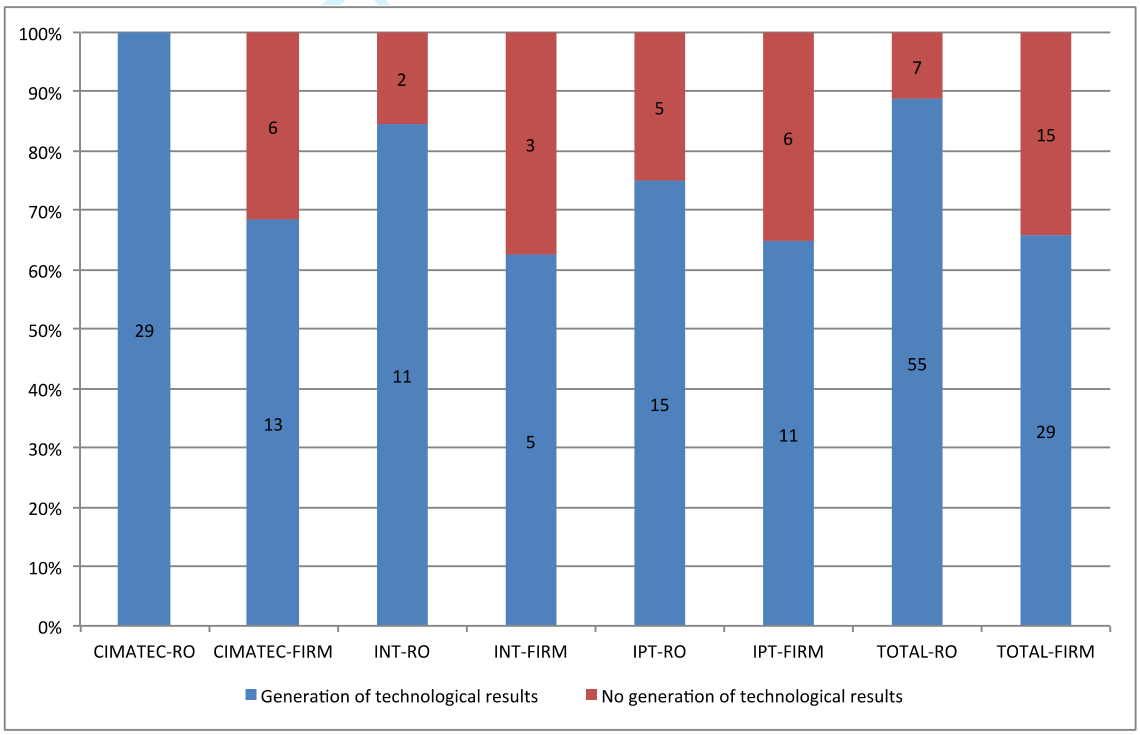
Technological results, innovation and capacity building

Beyond generating changes in RO's related to orientation and transaction barriers, it was expected from EMBRAPII's Pilot Phase technological results oriented to innovation. As results we understand all the developments accomplished by the project when it has reached the final stage of conclusion. These include: products, material, processes, equipment, software, methodologies, etc.

From ROs perspective, 89% of the projects generated some kind of technological result;

from firm's perspective, 66% of the projects did it. This reveals a more optimistic view of project executors about project's outputs in comparison to firm's understanding whether projects achieved or not with potential application. From the expert's perspective (I3), all of the 25 projects of the sample generated technological results. In just some few exceptions – maximum of 10% of the cases – results were not attributed to EMBRAPII in some degree.

Figure 3: Generation of technological results with potential application (number of answers)



Source: surveys I1 and I2

Regarding the degree of novelty of technological results, ROs and companies had slightly different perceptions: for ROs 17%, 48% and 35% were considered as new to the company level, country level and world level, respectively. From the company's perspective, these figures were 18%, 32% and 50%, respectively. As can be seen, companies had a more optimistic view over the originality of technological results.

Despite the pre-competitive nature of projects suggested in EMBRAPII's guidelines, it was meaningful to investigate innovation generation within the projects, since fostering innovation throughout research-industry cooperation is the long-term purpose of this policy. There were 8 innovations resulting from projects reported by firms. Innovation was considered the implementation – either by introduction or by adoption – of new or significantly improved products and processes. Seven out of eight of them came from CIMATEC's projects and 1 from INT. There were also 33 cases where innovation didn't happen but was strongly expected.

As anticipated, there were still few technological results that were introduced or adopted by companies. This occurred precisely because there is a normal temporal gap between obtaining a technological result and its implementation, since complementary assets are required to support successful introduction and commercialization of a technological innovation (as proposed by Teece, 1986). This explains why firms considered concurrent factors beyond EMBRAPII as influential to the generation of innovations.

When inquired about the cases in which innovations are expected for the future, experts pointed out the essential role of firms in providing additional investments in R&D and other complementary activities to support introduction or implementation of new products and processes.

As for the observed impacts of innovation in the partner firms, the expected results included:

- Added value of existing products/services;
- Higher quality of existing products/services;
- Cost reduction;
- Keep or expand the market share;

- Opening new markets
- Expanding productive capacity
- Expansion of portfolio of products/services;
- Increasing sales
- Reduction of environmental impacts

In terms of generating new scientific and technological capabilities, the results are quite positive. In exceptional cases the participant organizations – either firms or ROs – did not recognize the contribution of the projects in this respect. Most cases involve the new competencies, which also have created new lines of research or at least the consolidation of existent ones.

Nearly 2/3 of the projects reported generation of intellectual property rights from the perspective of ROs, while in the case of firms the figure accounted for 50%. EMBRAPII was considered highly influential in this process. Technological transfer agreements were reported in the case of several projects, also attributed to EMBRAPII's model.

The generation of technological results and competences brings evidence of output additionality. The aggregated analysis suggested that EMBRAPII model is working as predicted. Nevertheless, the medium and long-term consequences of EMBRAPII implementation are still to be measured.

Convergences and divergences between partners' perceptions

As showed in the previous items, there are distinctive perceptions among ROs, firms and experts about figures of some variables. Two indicators were created to measure misalignments between answers from project executors in ROs and project managers in companies: i) indicator of discrepancy of figures; and ii) indicator of opposition of figures – this one used to measure if answers had opposite directions.

Discrepancy and opposition between ROs and firms occurred with more emphasis over indicators of: project scope (if ideas investigated in the project were already being explored beforehand by the organizations), intellectual property, and allocation of personnel and material resources from firms in project development.

The degree of divergence of those indicators calls for a stronger governance over projects, particularly on establishing mechanisms to validate data generated by projects. In other words, although a comparative better model, projects'governance between partners still have to evolve in order to reduce transaction barriers.

Multivariate analysis

Although the small size of the sample and the presence of only three ROs in the Pilot Phase, we tried to find significant statistic regularities within the collected dataset. A multiple correspondence and a cluster analysis were carried out mainly based on selected variables of survey I1.

Three clusters were identified, with minor distinctions among them. Cluster 1 was dominated by CIMATEC projects (22 from this RO and just one from IPT); Cluster 2 had a more balanced constitution – 12 projects from INT, 10 from IPT and 8 from CIMATEC; finally, Cluster 3 had 8 projects from IPT and just 1 from INT and CIMATEC.

Cluster 1 was a little more successful in generation of technological results than the other two, while Clusters 2 and 3 had slightly more technology transfer contracts than the first. Firm's demands played an essential role in projects from Cluster 1, while the balance between demand and supply motivated projects from Cluster 2 and 3.

In terms of management practices, Clusters 1 and 2 were more similar and could be considered as more professionalized than Cluster 3. Still Cluster 3 seems less dependent of EMBRAPII, since this initiative contributed to projects already in development and with allocation of external funding resources.

This reveals the very nature of ROs, since CIMATEC is a private-non-profit organization created by industry to promote research-industry linkages, while the other two were reasoned in a state-owned management model, being more recently reoriented to foster such linkages; this is particularly the case of INT that compared to IPT has historically a stronger bias towards public-oriented research.

In other words, these analyses present evidences that previous context of ROs are relevant to explain some differences of behavior and performance under EMBRAPII's model. They also reinforce the common notion that organizational and behavioral transformations are expected to be tougher in organizations whose missions and culture are more driven by producers than by users of knowledge.

Conclusions and policy implications

Findings explored in this manuscript revealed that EMBRAPII's model had an important weight in promoting both behavioral and output additionality. That suggests the EMBRAPII's model has accomplished most of its initial intents. Beyond projects' output and outcomes, ROs improved their research and innovation management capabilities, such as those related to prospecting opportunities and partners, negotiating, contracting and managing projects and fostering new partnerships. These changes were not homogenous amongst ROs bringing evidences that organizational and cultural traits may have influenced the differences. All in all, there are evidences of behavioral additionality in ROs towards professionalization of R&D governance and management.

Concerning project outputs, findings showed that expected technological results such as new products, processes and methodologies, were achieved in the majority of projects. Although ROs reported higher accountings about these indicators, companies reported similar figures and revealed qualitative satisfaction with results. Intellectual property rights were generated in more than 50% of the projects, Moreover, projects contributed to the creation of new research areas or to the consolidation of existing ones - both in ROs and companies.

Experts hired to visit projects' sites confirmed results were original, technically relevant, and pre-competitive in their design and execution. Some firms were already able to use project's results in their internal processes or to commercialize the developed technologies, meaning that companies reported innovations based on project's results. Impacts related from these innovations are observed primarily in terms of added value and quality improvement, but also in cost reduction and market share.

As for removing orientation barriers (as pointed out by Bruneel, D´Este and Salter 2010), the model gives parties freedom to negotiate and operate and only allow projects to start after join definition of project's main subject, methodology, timeframe and expected results.

EMBRAPII's model requires parties to interact since the very beginning: from the prospection of companies interested in spending resources in R&D in a cooperative way, until the completion of a project (companies are formally demanded by EMBRAPII to give their final appraisal for project completion). They also have to engage in project monitoring.

From the transaction barriers standpoint, besides positive side effects from removing orientation barriers – as for joint negotiation and joint monitoring, EMBRAPII's model gives ROs a more flexible way to manage resources. These resources are awarded according to an Action Plan and can only be spent in projects where companies match funds with their own financial resources. Another characteristic that contributes to remove transaction barriers refers to the EMBRAPII's process of accreditation.

Amongst other requirements that can be seen in the EMBRAPII's model, ROs are stimulated to develop managerial standards to deal with collaborative industrial R&D projects – such as PMBok or related training in R&D project management. This forces organizations to professionalize their internal processes and their personnel adopting best practices of R&D management. It also induces a reorganization of governance standards at ROs.

Azevedo et al. (2016:35) suggest "the standardization of EMBRAPII's operating model provided operational benefits to ROs such as process controls, contracts and execution of projects that did not exist previously. (…) As a result, the new institutional design resulted in the acquisition of the capabilities of 'public-private collaboration' and 'experimentation and learning'." The authors claim that these new organizational skills developed by ROs are more conducive to triggering innovation within firms.

From a methodological point of view, the main contributions presented by this manuscript relate to the proposition and validation of indicators to measure input, behavioral and output additionality in similar research-industry collaboration policies, understood as increasingly important to develop ecosystems of innovation. This means exploring the design, characteristics and potential impact of policy instruments not only from the perspective of technology transfer towards private firms or the industrial sector, but also the joint development of research and managerial competencies in linkages stabilized by governance and managerial skills.

The main limitations of the study are as follows. (1) The impossibility of using control groups in the evaluation design, since the Pilot Phase was not organized by a competitive call from which awardees ROs could be compared with those not supported. (2) The timeframe used in the evaluation. As discussed in specialized literature, there is an ordinary temporal gap between obtaining a technological result and its implementation as innovation, as well as for consolidating management routines. In this case it can also be said that progress in the implementation of EMBRAPII could provide more adequate time frames for evaluation. (3) The low number of ROs in the Pilot Phase - just three research organizations - limits the conclusions.

Finally, despite the evidence presented here about the benefits brought by EMBRAPII Pilot Phase, further investigation on this subject is still needed. It should integrate the growing efforts to evaluate science, technology and innovation programs, and policies in multiple dimensions, as for the economic, social and environmental dimensions.

ANNEX 1 – List of indicators employed in all instruments

Indicator	I1	I2	I3	Redundant causality factor
Previous relations between ROs and firms	x	x		x
Willingness to cooperate		x		
Motivation to project development	x	x		
Negotiation time	x			x
Agility in delivering contracts in comparison with projects supported by public research agencies	x			
Creation of new management practices and organizational structures related to prospection and negotiation of partnerships	x			x
Specific factors of the EMBRAPII's model that facilitated prospection, negotiation and contract of projects from the RO's perspective	x	x		
Involvement of companies' human resources in project development	x	x		
Additional fund raising for EMBRAPII's projects	x	x		
Adoption of project management guidelines or project/portfolio management tools				
Creation of new management practices and organizational structures related to management and monitoring partnerships	x			x
Satisfaction with project progress and achievement of results		x		x
New partnerships between ROs and firms as a consequence of EMBRAPII's projects	x	x		
Specific factors of the EMBRAPII's model that facilitated the development of projects from the RO's perspective				
Generation of technological results	x	x	x	x
Degree of novelty	x	x	x	
Generation of innovation	x	x	x	x
Impacts of innovation (potential and observed)	x	x	x	
Generation of scientific and technological competences	x	x	x	
Generation of intellectual property rights	x	x	x	x
Generation of technological transfer agreements	x	x	x	x

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