Functioning strategies of the Research Groups' Leaders in the context of funding and policy instability[1]

ABSTRACT

We explore the strategies implemented by Research Groups' Leaders while coping with unstable contexts, characterized by incoherence and lack of coordination among different policy discourses and instruments, and scarce resources. We focus on a country where these conditions are present: Colombia. In doing so, we study two cases, one in nanotechnology and another one in biomedical engineering. Interviews, focus groups and workshops allowed us to identify and valide strategies grouped in four popular sayings, proper to local idiosyncrasy, highlighting the role of home institutions and principal investigators in facing such situations with resilience and resourcefulness, and even taking advantage of them. We find that Research Groups' Leaders use strategies such as: adapting, balancing agendas and funding sources, networking, and taking advantage of the support programs available at their home institution to continue functioning. These are setting the ground for a further survey which could pretend to some generalization. However, these should also be taken into account by policy agencies when defining policy instruments.

Keywords: Science, Technology, and Innovation Policy; Research Groups' Strategies; Principal Investigators; Research Groups' Leaders; Bottom-Up Perspective.

Practitioner Points:

1. Research Groups' Leaders (RGLs) and their PIs could adapt, articulate and combine several types of policy instruments and opportunities, according to their needs and interests.
2. RGLs could balance agendas, contexts, and resources, by maintaining their core research lines defined autonomously, while taking advantage of STI policies and articulating instruments and opportunities.
3. RGLs and their PIs could appeal to their networks, home institutions and recognition to continue pursuing their research agenda by assuring access to research tools and policy instruments.

1. Introduction

Research Groups (RGs) are key players to improve the knowledge base in society. They often operate in unstable contexts, facing incoherence and lack of coordination among different policy discourses and instruments, and, of course, scarce resources. We are interested in understanding the strategies Research Groups' Leaders (RGLs)[2] use to face such an environment and even, in some cases, take advantage of it in a resilient and resourceful way to 'survive' and even grow. We think this understanding could be fundamental for establishing policies and policy instruments adapted to the way RGs function, especially in scarce resource environments, like some univetsities do with specific instrument supporting the research continuity of their own RGs.

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[1] An earlier version of this paper was presented at the International Conference: The Transformation of Research in the South: policies and outcomes, OECD, January 21 and 22, 2016, Paris.
[2] Regarding the use of RGL and PI (Principal Investigator), see section 2.2.

Policy uncertainty is a constant scenario in the Global South[3], and increasingly in the Global North. Its effects on local Science, Technology, and Innovation (STI) systems have become a growing issue of analysis (Kuhlmann and Ordóñez-Matamoros, 2017). However, most studies have focused on cases in the Global South, in locations such as: Venezuela (Diaz et al., 1983; Laya, & Vessuri, 2019), Burkina Faso (Hermann et al., 2012), India (Priyadarshinia and Abhilash, 2020), Brasil (Fraundorfer and Rabitz, 2020), and arabic-speaking countries (Currie-Alder, Arvanitis et al., 2018; Currie-Alder, Cundill et al. 2020), among others.

Several sources of instability are identified. First, incoherence and lack of coordination amongst changing and diverging policy discourses are common and result in the implementation of policies involving competing goals. A classic example is the contrast between sustainability policy goals and development policy goals and its consequences on STI policy making and practice, or Higher Education policies that encourage universities to have research journals at the university, while STI policies encourage the existence of 'highly ranked' journals only, therefore leading to contradictory signals and rules of the game at universities as to what the government prefers (Ruiz-Serna et al., 2018).

Second, instability also comes from incoherence amongst instruments following the same policy goals but with contradicting, duplicating or neutralizing effects on each other, within or at different governance levels (international, national, sub-national or institutional). Examples include instruments focusing on strengthening the intellectual property rights (IPR) regime versus those improving open access strategies; or those that "push to connect with 'best-in-world' [ignoring] opportunities for regional collaboration" (Currie-Alder et al., 2018, p. 7). According to Chaminade and Padilla-Pérez (2017) in nearly every country there are coordination and competition problems among public organizations in charge of STI policies and related areas (i.e. economy and education).

Third, instability also comes from discrepancies between policy discourse and instruments implemented. Guzmán Tovar (2015) found "a gap between the level of discourse and the level of practice", (p. 138)[4] in the Colombian, Mexican and Argentinian STI public policies. According to Kreimer (2015), the processes governing the STI dynamics highlight a sheer distance between conceptualization and practice. This distance results from the fact that STI policies in emerging countries are often replicating existing instruments from the hegemonic countries, overlooking their own specific STI dynamics (Arocena and Sutz, 2006, 2017; Kuhlmann and Ordóñez-Matamoros, 2017).

Furthermore, in some cases, RGs are the ones expected to attain policy goals without considering their specificity and own challenges and agendas. A situation that some authors call "policy-based evidence" (Strassheim and Kettunen, 2014) forcing RGs home institutions (HI) to comply with some scientometric indicators and, in doing so, to respond to policy instruments' requirements that are seen as not relevant or inconvenient, and leading questionable effects: more emphasis on excellence than on relevance, the exacerbation of the 'Matthew Effect' (Merton, 1968), and even unethical behavior. This situation may be related to some efforts to strategically govern universities as a whole, as well as at the process

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[3] 'Countries in the Global South', 'emerging economies' and 'developing countries' are not synonyms. They refer to different conceptual and politcal approaches. However, in the case we have investigated, these termes all apply. For the paper, we choose to use 'emerging economies', but we also keep the terms as used by the authors cited for easy reference.
[4] Translated by the authors.

level (Parakhina et al., 2017), with a focus on indicators, especially for R&D activities (Feng et al., 2004) and on incentives as a key motivator for academics' performance (McCormack et al., 2014).

These 'governance challenges' are particularly important in emerging economies (Kuhlmann and Ordóñez-Matamoros, 2017), although there have been cases in the Global North. E.g., in Sweden, where the redundancy of policy instruments causes problems, like agglomeration effects, having beneficiaries receiving resources from multiple sources (Hallonsten and Hugander, 2014), and difficulties in harmonizing the funding efficiency with academic excellence and utility of research (Cocos, 2020). Similar situations have been found in the Czech Republic (Good, et al. 2015) and in Norway (Arnold & Mahieu, 2012).

Finally, scarce resources are another common denominator for RGs in general (Cruz-Castro and Sanz-Menéndez, 2018), and specifically in non-hegemonic or less developed contexts (Gaillard et al., 1997), where both relative and absolute values spent on R&D, in terms of GDP, are indeed marginal.

In summary, this unstable context is characterized by inconsistencies between policies, between policy instruments used for their implementation, and between policy discourses and their associated instruments (or their absence) and, by scarce resources. These inconsistencies refer to contradictions, divergence, competition, or lack of coherence that could result from a lack of coordination at national governance levels or from translation problems of the policies into instruments. They can create both problems and opportunities for RGs.

The goal of this paper is to shed some light on the way RGLs are facing this unstable environment to keep their RGs functioning. We do so by looking at micro-level strategies, and by studying the choices with respect to the set of policy instruments and discourses that surround or influence research practices. Following Kuhlmann et al. (2010), and Kuhlmann and Ordóñez-Matamoros (2017), we refer to the 'Innovation Policy Dance' metaphor where, inter alia, RGs learn from the policy domain like in a "dance", adapting their "dance steps" to to take advantage and exploit the opportunities (or avoid new burdens) opened before them. We claim that understanding how RGs react to policy can help designing and implementing better policies and instruments in contexts similar to the ones studied here.

To reach our goal, we test some propositions based on current literature and use popular sayings as a basis for a process of conceptualization of the strategies of the RGs. We specifically look at the role of the leaders of two RGs in Colombia: one specialized on nanotechnology and another one on biomedical engineering. We also look at the role of HI as key actors of RGs in such contexts. It's important to note that we don't intend to generalize the lessons learned by studying these two cases and by the validation of the results through workshop with a panel of RG leaders. The ambition of the paper is to set the ground for further representative surveys. Furthermore, we chose to study two RGs that present particularly successful results, even though they face the same challenging context. We claim that this is insightful for those RGLs and policy makers who may find similarities to their own contexts, but furthermore for setting up a relevant survey which could test the general validity of the strategies identified and documented, and their explaining variables.

In the following sections we discuss the strategies of RGs and their RGLs as key drivers of change and stability and the role of their HI. We then introduce the research question and

propositions, then the methodology, the findings using the two cases analyzed, and, at the end, we offer a discussion on some policy-and-management-related implications, to finish by pointing to future research.

2. RG's, Leaders and Home Institutions

In the following sections we describe the strategies of RGs, their Leaders and the role of the HI when coping with instability.

2.1. Research Groups

Since the 1980s, many authors have studied RGs as actors, bearers of projects and research strategies (Darmon et al., 1982). Observing them over time, some authors have differentiated their strategic profiles (Larédo and Mustar, 2000) or trajectories and show that their differences relate to their context of action, and to their internal dynamics. RGs define internal and inter-organizational rules to perform actions and achieve their objectives (Dutrénit et al., 2018; Louvel, 2010, 2011), considering strategies, resources and constraints, given their institutional context (Vinck, 2010). RGs also work as a protection for research projects. They combine several types of resources to locally support the nascent projects until they achieve sufficient strength to meet external quality requirements and compete (Vinck, 1992) or to collaborate internationally (Ordóñez-Matamoros, 2008; Ordóñez-Matamoros et al., 2010), supporting long-term projects and research agendas (Dutrénit et al., 2018).

RGs not only adapt to the challenges and opportunities they face, but design strategies (López-Yáñez and Altopiedi, 2015) in the face of tensions and contradictions between the conditions of funding and autonomy in research processes (Aagaard et al., 2021; Hubert and Louvel, 2012) and goals (e.g. social impact, Van der Weijden et al., 2012). So, RGs interact with, and adapt to, STI policies, instruments and funding constraints, learning from these interactions and developing their own strategies (Chaminade and Padilla-Pérez, 2017; Kuhlmann et al., 2010; Rip and Nederhof, 1985).

Although the fact that RGs indeed strategize is not new, we propose to qualify some of these strategies, in an unstable context, using sayings to characterize them. For doing so, we explore the role of RGLs as key actors.

2.2 RG's Leaders or Principal Investigators[5]

Several authors have highlighted the importance of Principal Investigators (PIs) for RGs performance. López-Yáñez and Altopiedi (2015) show that they have a significant role in the pathways and organization of the RG at distinct stages of development. Santos and Hugo

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[5] This section analyzes the literature on the role of the Principal Investigator (PI) in research project contexts. For the Colombian case, we will refer to the RGL, since this form of organization is strongly institutionalized in the country. Colombian STI policy gives priority to RGs and their leaders; RGLs act, in addition to being a leader, which involves the strategic orientation of the group, as PI, which is the role the literature mainly studies. The two terms are not synonyms. The first one refers to research groups inside a research institution; the second one refers to research project which can be interinstitutional. However, in the cases analyzed, the group leaders are also PIs. For this reason, in this article we will use the notions of PI and RGL in an equivalent way. We use the term PI when we refer to the literature.

(2020) suggest an association between their research conceptions (e.g. scientific ambition or society-driven) and their setting of the research agenda. The commitment of the RGL in its RG, and in networking provides visibility and contributes to improved academic performance (Verbree et al., 2015). Furthermore, according to Kastrin et al. (2018), PIs 'drive science', as they outperform the average researchers regarding publications, collaboration, international co-authorship and interdisciplinarity, while for Göktepe-Hultén (2008) RGLs are relevant for the entrepreneurial culture at universities.

Some funding agencies require major management, bureaucratic and reporting efforts ('transaction costs'), decreasing the benefits obtained from them (Cunningham et al., 2014; O'Kane et al., 2020; Ordóñez-Matamoros, 2008; O'Reilly et al., 2010). O'Reilly et al. (2010) also highlight the significant role of the PI in terms of strategic management; given their responsibilities "beyond scientific leadership to the core functions of management – planning, leading, organizing and controlling" (p. 30). This highlights the importance of skills to obtain and manage resources according to the requirements of the funding agencies[6]. Facing lack of coordination among supporting institutions, duplicity of policy instruments (Hallonsten and Hugander, 2014), discontinuity in funding programs, and low levels of investment, PIs are expected to act as project managers, "scientific entrepreneurs", science networkers and research contractors (Cunningham et al., 2015; Mangematin et al., 2014; O'Kane et al., 2020).

PIs act as entrepreneurs in academia who, according to their vision, goals, and expectations, "strategize their action", "resource their strategy", and shape the organization (Mangematin et al., 2014). They not only adapt to the policy constraints and dynamics, but they sometimes shape the relationships with policies and policymakers in a proactive way, even creating new scenarios (Rip and Nerderhof, 1985; Callon, 1984). They indeed play a boundary spanning, broker, and other bridge functions (Long et al., 2013). Investigations in Colombia show that such boundary-spanning function (Herrera et al., 2006; Jaime et al., 2016) is crucial to defend a research agenda (Perez Martelo et al., 2015).

PIs have either a reactive or a proactive posture according to their conformance to existing research trajectories. PIs facing changing contexts of public funding can turn into: research designers (defining a core research program and selecting funding sources), research adapters (moving inside a broad research focus allowing to seize emerging issues and accessing various funding sources), research supporters (securing and strengthening the trajectory), and research pursuers (managing short-term research agendas, responding to funding sources calls) (O'Kane et al., 2015). To obtain resources, the PIs mediating relations in collaborative networks allow them to position themselves to get access to resources (knowledge, information, funding, and human resources) more than those working in relative isolation (Ebadi and Schiffauerova, 2015). This also implies the ability to manage and combine multiple sources of funding (Aagaard et al., 2021). In the case of Latin America, the training of researchers from this region in elite centers abroad has played an important role in the ability to form international networks (Feld & Kreimer, 2019a, 2019b).

Grounding on this literature, we wonder how PIs act within their RGs to function given unstable contexts. Considering that RG's actions are dependent on their HI, we now discuss their role.

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[6] In Colombia, for example, bilingualism of URG leaders has been identified as a good predictor of team's international collaboration and productivity (Ordoñez, 2008).

2.3 The role of home institutions

While some authors study intermediary institutional levels (e.g., university council) or draw attention to them (Rip, 1988), few investigate their mediating role between the national or international STI policies or agencies, and RGs, their strategies, and trajectories, in a context of uncertainty and lack of stable resources.

In national research systems, universities are one of the main actors as HI of RGs, generating contributions to the national, local, and regional economies. Many research universities provide start-up funds to equip young researchers' laboratories and conduct initial research. After that, researchers are expected to obtain support from external grants (Atkinson & Blanpied, 2008).

However, according to Gomez-Buendía and Jaramillo (1997), the university may be a hostile or friendly habitat to RGs. Currie-Alder et al. (2018) show that, in Arabic-speaking countries, the pressure to "publish or perish" or the "teaching and training duties" (p. 80) can inhibit working on local problems or potentially novel issues.

Universities face global standards, rankings, and the New Public Management, which require internal reforms, following similar rationales, with important national differences (Medina et al., 2014) and diversity given the way universities position themselves regarding standards, access and use of resources, organizational culture and governance, and inscription into the local milieu (Paradeise and Thoenig, 2015), where they involve themselves in setting up local STI policies[7] (Vessuri, 1998). Also, universities are starting to build their own policies, establishing internal systems for promoting research and allocating resources, adapting models from various levels of STI policies (Cancino et al., 2021; Haake & Silander, 2021; Luwel, 2021), sometimes adding complexity to the RGs environment. For Van der Meulen and Rip (1998), university councils act as intermediaries between the (inter)national policies and RGs performance. Their relationship is "a back-and-forth of constructing demands, of localized and idiosyncratic interpretations of policy discourses, and of material and structural constraints in practice" (Åm, 2013, pp. 497).

We now discuss in more detail the specific research question we address in this paper.

3. Research Approach

This study aims at contributing to a better understanding of how PIs "navigate" through unstable conditions to make their RGs function. To do so, we study how PIs deal with uncertainty and discrepancy amongst STI policy discourses and instruments, and scarce resources, in the Colombian context.

3.1 Colombian context

Colombia is a good case study, as uncertainty there abounds. First, the lack of funding for STI in Colombia is a well-known problem, where the share of the GDP spent on R&D is among the lowest in the region: less than 0.3% (Cotte Poveda et al., 2018; Pardo Martínez y Cotte

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[7] An interesting example in Argentina, is shown in Correa (2014).

Poveda, 2020)[8]. Second, after two centuries of major political instability, in 1969, a national STI system was shaped till the 2009 turn toward innovation and broader societal goals with no additional resources, which led to fragilize the research system, its governability and its legitimacy (Vinck, 2018). In the last decade Colciencias[9], the leader of the Colombian STI System, and its National Policy, has had about one director per annum, everyone with his/her own agenda, which generates instability. Finally, after one year of operation of the newly created STI Ministry, the Constitutional Court declared its founding law unconstitutional. To summarize, between policy discourses and the implementations, there have been many inconsistencies: the funds invested do not reflect the objectives formulated. Science is relegated over other areas such as national defense, while it has become an enhancer of the business sectors, but the agendas or programs for the consolidation of national science and its regional networks are weakly supported.

The discourse also incorporates notions of systems and networks, but they are more rhetorical than really implemented (Guzmán Tovar, 2015). Incoherence among policy instruments is seen in the efforts aiming at encouraging researchers to work together into networks (Cancino et al., 2014; Velho, 2004) and RGs (Orozco et al., 2013), because Colciencias establishes metrics for the categorization of RG[10] that favor competition over cohesion. These instruments have played a crucial role in the consolidation of the Colombian STI system, but they have also brought instability as the criteria used have been frequently changed, adding complexity to an already complex system.

We note that contrary to problems of agglomeration effects given the "redundancy of policy instruments" (Hallonsten and Hugander, 2014), in Colombia the difficulties are linked to coordination problems among the funding agencies, where the scarcity and low continuity of resources limits the agglomeration, but implies using different sources to fill gaps left by the available sources. This is consistent with the harmonization problems described in other countries (Cocos, 2020; Good, et al. 2015; Arnold & Mahieu, 2012).

Other sources of uncertainty include the strict Intellectual Property Rights - IPR instruments and norms implemented, which go against the policies strengthening open access in the country (Departamento Administrativo de Ciencia, Tecnología e Innovación - Colciencias, 2018), some calls for proposals for supporting technology transfer initiatives, where Innpulsa (the Colombian Public Agency in charge of Innovation and Entrepreneurship) competes with Colciencias, opening separate calls with very similar purposes, and the difference between the Colombian policy on biodiversity research and the procedure established to obtain a biodiversity research study permit, which has hindered biodiversity research activities (Güiza and Bernal, 2013).

3.2 Research Methods

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[8] A detailed explanation on the STI policy and funding changes in Colombia can be found in Correa, et al. (2014). Also, an explanation of the changes in the governance of the Colombian system of science, technology and innovation can be found in Salazar (2017)

[9] Colciencias (Departamento Administrativo de Ciencia, Tecnología e Innovación), nowadays a Ministry (Minciencias), since the law 1951 (2019) that "Creates the Ministry of Science, Technology and Innovation, Strengthens the National Science, Technology and Innovation System and Establishes Other Provisions".

[10] We use RG to refer to research groups that may or may not be ascribed to universities, thus including other organizations that also do research.

Within the range of questions that may arise about STI theory, policy and practice considering the research contexts depicted, the specific research question we aim to respond is: ***What are the strategies implemented by the RGLs to operate in the context of instability?*** We are particularly interested in how RGLs in Colombia deal with constant policy changes, inconsistencies and uncertainties as the ones listed before, and what roles HI play. To answer this research question, we followed an abductive approach (Reichertz, 2010) consisting of the construction of propositions, and their confrontation with case studies (Yin, 2013).

In the first step, propositions were based on literature and firsthand experiences of the authors. We contrasted and enriched them based on the study of a RG working in the nanotechnology field, the "Grupo de Investigación en Fisicoquímica Teórica y Experimental[11]"– GIFTEX (Authors - Anonymized for peer review, 2016), located at a Colombian public university, the "Universidad Industrial de Santander" (UIS), in a mid-size city (Bucaramanga). This group was created in 2004 and works on fundamental and applied physical chemistry. Its research focuses on cellulosic materials. This group has been working on the development of a technology aiming at the decontamination of water based on nanocomposites. Additionally to project documents nalysis, a onr hour in-depth interview was made to its RGL. It took place on september 25th, 2015, and was recorded and transcribed.

In the second step, we took advantage of a previously documented case (Authors - Anonymized for peer review, 2012) about the Biomedical Engineering Research Group[12] (IB), located at a private university, the "Universidad de los Andes" (Uniandes), in Bogotá, the capital of the country. The IB group was created in 1985 and works on biomedical engineering. It focuses on hemosubstitutes and tissue engineering, among other subjects. We centered our observations on the hemosubstitutes work. We also administered an in-depth interview to the RGL of the IB Group to deepen our understanding of the matter as well as to further validate and refine the propositions.

Although allegedly similar behavioral patterns may be found in other scientific fields, we opted for focusing on these two RGs whose results, in terms of publications, graduated students, patents and other "products", surpass the ones observed in most groups. Both groups are intensive in laboratory infrastructure (although not comparable with some ones found in developed countries), and their work requires materials and seeks applicability. Furthermore, the relationship with the industry is subsequent to their consolidation in research. These aspects, according to Whitley, Glaser & Laudel (2018), are determinant to understand the strategies implemented by the groups, which are discussed in more detail below.

As a complementary effort, we analyzed several studies on the RGs working conditions in the country, their belonging institution, scientific dynamics, strategies, productivity, and orientation (Gómez Buendía and Jaramillo Salazar, 1997; Jaramillo et al., 2006; Lucio-Arias et al., 2020; Ordóñez-Matamoros, 2008; Orozco et al., 2013; Ruiz et al., 2009).

In the third step, and as a result of the documentation, interviews and their analysis, we assessed and further improved the propositions and translated them into popular sayings. We

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[11]   RG on Theoretical and Experimental Physical Chemistry. This group worked in close collaboration with another group called Centro de Estudios e Investigaciones Ambientales (CEIAM).

[12]   IB by its name in Spanish.

organized two workshops, which were held in August 11th and October 31st, 2016, in Bogotá[13]. The first workshop lasted 3 hours and 39 mins. The second one lasted 2 hours and 26 mins. Around seventy people participated in these workshops, including: researchers and RGLs from different disciplines – some of them having much experience in national and international research councils and Colombian STI policies and a good overview of the variety of RGs in the country –, research policy scholars and HI managers. The propositions, translated into popular sayings, were tested with the participants. This helped to motivate lively and provocative discussions and made their identification easier. It is worth mentioning that the PI of IB participated in the first workshop, which allowed us to complement the information previously gathered. The discussions referred to reconfiguration strategies, dynamics and implications RGs consider, while dealing with multiple needs, opportunities, barriers, and limitations resulting from STI policies and their associated instruments at the national, regional, and institutional levels in Colombia. Both workshops were recorded and transcribed. In each workshop, the authors administered a poll among the participants aiming at, once again, assessing the propositions. The poll was conducted based on the methodology proposed by Reyes (2008) where, taking advantage of episodic memory, participants react to cartoons portraying different scenarios[14]. This exercise was complemented by a voting system which yielded results the participants could see on the screen and contrast their responses with the group's outcomes. Thirty responses were gathered.

As a fourth step, we analyzed the cases from the perspective of the propositions as they were evolving. With the idea of tackling the issue of instability, we chose to focus on a technological development project (nanotechnology for the solution of environmental problems through the enhancement of natural fibers) carried out by the RG GIFTEX, as well as on the work on hemosubstitutes of IB. It is important to note that case studies have shown their usefulness for building lessons in the context of STI policies (Goulet, & Hubert, 2020; Stezano, 2018).

it is worth mentioning that we understand the notion of 'project', not in the administrative sense of a unity of research (as defined by a start date, a completion date, some objectives, a budget, the name of a list of researchers and the resources available), but more as a unit that makes sense for researchers beyond institutional frameworks. Consequently, we began to study the trajectory of these projects to develop a technology and identified various actors, resources and policy instruments mobilized by the RGLs in their effort to maintain their strategies and research areas they have established. In addition to the semi-structured interviews, active ethnographic observation and a collection and analysis of documents (related to STI policies, policy instruments, project documents, scientific publications, press releases and work documents), help to reconstruct the trajectory of the projects and the actions of the RGLs to understand how they articulated various resources and simultaneously took advantage of several STI policy instruments and other opportunities available.

Hence, from the question posed, we assessed the following propositions and sayings referring to the strategies of RGLs (3), and one referring to the role of HI:
   P1. "I dance according to the tune": Adapting. The RGLs interact with uncertainties and opportunities and have learned to take advantage of them, articulating and combining several types of policy instruments and opportunities, according to their needs and

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[13]   The recordings of these workshops are available on Youtube (in Spanish).
[14]   These cartoons are available on demand.

interests. We base this proposition on studies such as the ones done by Kuhlmann et al., (2010) and Kuhlmann and Ordóñez-Matamoros (2017), among others.

P2. "Performing a juggling act": Balancing agendas, contexts, and resources. The RGs maintain research lines defined autonomously, which do not depend on STI policy instruments. This proposition also highlights the key role of the PI in taking advantage of STI policies and articulating instruments and opportunities. We base this proposition on studies such as the one done by Mangematin et al. (2014), Cunningham et al. (2015), and O'Kane et al. (2015), among others.

P3. "If you snuggle up to a tree with good branches, you will have a blanket in its shade": Networking. In the framework of STI policy incoherence between the national and institutional levels, some RGLs appeal to their networks and recognition to continue pursuing their research agenda via, for example, assuring access to research tools. We base this proposition on studies such as the one done by Ebadi and Schiffauerova (2015), Jaime et al. (2016), and Herrera et al. (2006), among others.

P4. "Mother there is only one": The role of the HI. The institutions to which RGs belong play a significant role in filling gaps left by policies and instruments at higher levels (regional or national) and opening new opportunities. We base this proposition on studies such as the one done by Van der Meulen and Rip (1998), Gomez Buendía and Jaramillo Salazar (1997), Åm (2013) and Vessuri (1998), among others.

4. How do RGs strategize?

The following sections describe RGs strategies to deal with the unstable context characterizing the Colombian STI System using the propositions and sayings described before. Since the GIFTEX case was the most studied, we focus on it and add references to the other case wherever it was found relevant.

4.1 "I dance according to the tune": adapting

The studied RGs trajectories show that they take advantage of the resources, infrastructure, and networks they have available to adapt to the possibilities open to them through national and international funding opportunities. Both RGs have interacted with a variety of actors in Colombia and abroad, which facilitate their taking advantage of different funding avenues, while preserving their research agendas.

At the beginning, in 2005, the GIFTEX group was contacted by the Secretary of Agriculture of the Department of Santander to explore the possibilities of working with sisal. As a result, they presented a project proposal, but they did not get funded because the Secretary later prioritized other themes. They had previously sought resources to work with sisal through the Ministry of Agriculture, unsuccessfully. At that time, regional entities prioritized sectors such as cocoa, and the group participated in some projects in these areas to "survive". Given the lack of resources from a formally funded project, the group continued to do research on sisal through undergraduate degree projects. This allowed them to have some initial results for presenting other project proposals later. It then developed initiatives for which it found some funding, without walking away from their core research interests (cellulosic materials). Subsequently, the Government of Santander made a call for proposals to support projects aimed at obtaining new materials from biodiversity in the region. GIFTEX found here an

opportunity to present a project on the use of sisal, identified as a promising research topic in the region.

In this context, the RG worked on some projects that enabled it to mobilize resources in the short term, enough to remain active and sustain other projects with greater long-term potential, and, in this way, to stay 'alive' as a group by using the link with teaching and the operating resources of the laboratories in the university.

In this case, the RGL, shows a learning process about how to mobilize various types of resources inside (students, colleagues, among others) or outside the university. He learned to move between (institutional, regional, national, and international) policy instruments to develop the RGs' agenda, in a process of articulating interests with opportunities. In this sense, agendas or topics are developed by "dancing according to the tune", that is, maintaining a minimum research core but adapting to the changing financing conditions. In doing so, the RG runs research programs on topics more or less independent of its externally funded projects and prepares project proposals trying to blend STI policy instruments with its own research needs. It is not a totally reactive process of responding to the funding organizations, but of "dancing according to the tune" by changing the pace and adapting to the moves made by their dancing partner (funding organization), within the limits of one's ability.

The case study shows that the RGL learns how to generate translation processes in the sense of Callon (1980) or, as Teece (2000) posits, develops dynamic capabilities regarding the building of research and strategy agendas among different actors, mobilizing them and rethinking their definition. In this way, the RG articulates policy instruments with its research interests.

This dance between the strategies of the RG and the policy instruments resulting in research initiatives kept the group active while working on other topics considered more promising in the long term by decision-makers. The group, in turn, maintains projects that compete among themselves, some of which subsidize other initiatives less attractive to funding agencies in the short term. This shows a permanent dance between the interests of the group and its context.

The RGL has learned that there are greater chances of getting resources for applied research projects. Therefore, they permanently monitor funding sources, including those that contrast with their research interests. A central element of the strategy of the group has been building a research core that can be flexible for multiple applications. In this way, according to the RGL, the group can have projects targeted to each application "without needing to reconvert … completely".

GIFTEX developed a project with a Colombian hydrocarbon company, but funding was suspended due to the crisis in that sector. This led the RGL to propose a redefinition of the strategy. The project with the company allowed them to fund graduate and doctoral students, as well as a postdoctoral fellow. Since the funding was suspended, the group strived for finding resources from other sources such as scholarships from Colciencias and the university, but it was not always possible and some people left. In this context of multiple policy instruments, the group learned to move to maintain its research core, but the ability to retain students that continue their doctoral education is low given the impossibility to secure funding.

The PI's strategies, in this case, correspond to the type called research adapters (O'Kane et al., 2015), where he mobilizes his group to keep their research subject. This case supports the first two propositions: the ability of the RGL to act and learn to act with STI policies and

the maintenance of its research core.

The ability of RGs to "dance according to the tune" and therefore take advantage of the partner (funding agency) and melody (policy discourse) was found to be a frequent strategy used by RGs. In the case of GIFTEX, one core subject (nanomaterials) was adapted to the different calls for proposals to continue researching. In the case of IB there was no evidence of this, but many of the workshop participants stated that accepting conditions of calls is a widespread practice and that sometimes conditions are either irrelevant or inconvenient (i.e. patenting research results as a condition to obtain funding). This case depicts how RGs harness inconsistencies at the policy level, where RGs 'play the system' while complying with diverse expectations, henceforth tapping on resources available.

4.2 "Performing a juggling act": Balancing agendas and funding sources

The cases show various components of the RGL performing juggling acts among STI policy instruments. Both IB and GIFTEX are examples of some RGLs' ability to combine instruments. They lean on diverse sources of financing, which include: Colciencias, Ministry of Health, university grants, private funding, and scholarships, to buy lab equipment, encourage the participation of students in the RG, and postulate PhD candidates at their main research partners, among others. Their RGLs work on balancing the opportunities of STI policy instruments and the RG agenda. This has allowed the development of several technologies. In the case of IB, hemosubstitutes, while in the case of GIFTEX, nanomaterials. Both RGs funded the first spin-offs of their universities, which are among the very few in Colombia.

One aspect where juggling is observed is the distribution of part of the available resources across areas with financing to others that have no support but are relevant to the group. The RGL of GIFTEX stated: *"we rely on the resources that come to support a project to permeate other projects of lesser amounts"*. These resources are harnessed to start developing new subjects that may become strategic or perceived as promising in the long term – according to GIFTEX's RGL, topics being *"cooked at low fire"*. The RGL learns how to leverage resources to work on new areas for which there is no formal funding. According to the workshops, researchers juggle given the shortage of resources for research projects in national policy instruments.

RGLs learn to diversify their funding portfolio *"performing juggling acts"* to avoid dropping the core topics while opening new research possibilities. They generate strategies to manage areas of research with different time horizons and speeds. Although having to perform juggling acts is not an ideal situation to manage RGs, having such ability is indeed key to keep running research agendas in uncertain scenarios such as Colombia.

Both cases studied, and the workshops, show that the RGLs develop strategies to maintain a core research agenda and strengthen their different research lines with multiple support programs. The unstable context led the RGLs to learn to balance, for instance, research agendas and financing opportunities opened for 'hot topics' in the short-term, while other research subjects are worked temporarily on the side, while new funding opportunities open in the future. Performing a juggling act allows the RGL to learn to combine exploitation strategies (areas for which they have a solid knowledge base) and exploration ones (new areas with potential but highly uncertain) (March, 1991) associated with unstable funding sources (O'Kane et al., 2015). The cases studied show the efforts aimed at balancing both strategies, while striving for survival in the framework of scarce resources and limited national

support. The balancing effort relates, not only to processes of knowledge generation, but also to the combination of policy instruments and funding opportunities.

One conclusion is that the ability of RG to take advantage of STI funding opportunities depends on collective activities. Although the role of the PI is determinant, harnessing STI policy instruments requires RGs members' abilities and support. PIs are necessary but not sufficient for RGs. In fact, the workshops revealed the importance of having several RGLs to thrive, configuring a human-based "*swarm intelligence*"[15]. According to some participants, teams require leaders that function on behalf of groups' interests, acknowledging that, as the popular saying goes, "one swallow does not a summer make." Summarizing, RG performance depends on both the PIs and all the other members who complement PIs' efforts, contributing to the groups' overall achievements.

4.3 "If you snuggle up to a tree with good branches, you will have a blanket in its shade" - The role of networking

Sometimes performing a juggling act depends on the abilities of the PI to move through the existing policy instruments and balance research agendas and needs. This involves, for example, capitalizing on personal networks. This is shown in the case of GIFTEX with a project funded through the "Program for High Recognition Diaspora"[16] developed in collaboration with a Colombian researcher ascribed to Cornell University (United States), who graduated from UIS and works with fibers enriched with nanoparticles and with whom they ran into at an international conference.

In the case of IB, personal networks are used to foster the activities of the RG. Access to robust equipment has been supplied by Georgia Tech laboratories for experimental testing. This was possible thanks to the connections that IB's PI kept with the institution where he did his PhD. This created opportunities for IB students to advance in their research careers, allowing them to access Georgia Tech labs while participating in IBs research initiatives.

The workshops also show that the group benefits from the networks of all its members. Positive results for RGs arise from combining several policy instruments, sometimes transcend the national frontiers, take advantage of institutional policies and even personal contacts and resources.

4.4 "Mother there is only one": the role of the home institution

As discussed above, continuity of the research streams is achieved because the RGL learns to combine policy instruments to support specific projects with other support programs, such as the ones available at their HI. By taking advantage of these instruments, RGs can continue their work, even in the absence of formal research projects.

In the case of GIFTEX, at UIS there are several programs to support research, such as: full and partial scholarships, the mobility program, and the infrastructure development program. These programs facilitate capacity building (Teece, 2000). The mobility program allows

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[15] The 'swarm intelligence' concept is borrowed from the literature on computing sciences. An adaptation of the concept in the business literature can be found at Bonabeau and Meyer (2001).
[16] A program from Colciencias aiming at strengthening links between Colombian researchers and innovators living abroad.

researchers to participate in academic events to meet with external peers, and explore project ideas to work on later, using, for example, an instrument of the national STI policy such as the Colciencias' Diaspora Program. In this case, the university becomes a relevant actor to fill gaps left by STI policies.

Another example is the scholarships that allow students to continue working on research projects, while they have access to resources from national programs like the Colciencias fellowship. According to the interviewee, and as discussed before (see section 4.1), some students who participated in a project with an oil company, which was suddenly stopped, received university scholarships while they were "preparing to participate in the next Colciencias' call for PhD scholarships." The institution provides basic support in the absence of other sources of funding to continue their research. The way the RGLs or the RG moves in the institutional environment strongly influences the ability to use those instruments.

Within the infrastructure development program, the university has strengthened a technology park with specialized laboratory equipment. This has allowed the continuity of the work of the RG and its positioning in front of its allies. According to GIFTEX's PI the University's support programs allow them "*to start working on some issues and having some initial results to obtain financing later*". For researchers to have the infrastructure and resources within their institution becomes a key support to progress, which is common with laboratory equipment (Suárez & Dutrénit, 2015; Vinck, 2006; 2010). Thanks to this, the group has strengthened its capacity to access international resources and generate more symmetrical international collaborations, as shown by Gaillard & Arvanitis (2014). This case illustrates that the HI may have a key role in dealing with unstable funding contexts, given the regional or national STI policy landscape, by providing resources for exploration in areas that may have external funding in the future. The role of the RGL, and how he learns to move along in the institutional environment and combine resources from different STI policy instruments, is key to keep the RG's activities.

Through the workshops, we also found that sometimes there can be several 'mothers' supporting RGs in complementary ways. This is the case for IB, for example. From the beginning of its work, it was necessary to establish a partnership between Uniandes & Fundación Cardio Infantil (FCI)[17]. This is a co-invention network (Herrera et al., 2012) that has worked on the development of a hemosubstitute (artificial blood). In fact, many of IB's research endeavors have involved both institutions, which has led IB's leader to express he considers himself as benefiting from "two mothers".

HI play fundamental roles for RGs, who typically operate under unstable conditions in countries like Colombia. In the GIFTEX case, for instance, UIS was key to increasing the RG's negotiating power with its international peers, through the provision of high-tech infrastructure. Thus, policy impacts depend on the RG and on their HI, which materialize STI policy ambitions by dealing with constant gaps left by policies and instruments designed at the national/central level.

HI can also play negative roles. According to some researchers attending the workshops, HI can also act as a 'burden' for research. For example, some universities require a substantial amount of time for teaching; lack agile processes, appropriate financial resources, managerial support and clear institutional policies for participating in externally funded programs; or lack the appropriate infrastructure to access key research resources and materials to do high

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[17] Cardiovascular Children's Hospital

quality scientific research.

It is worth noting that the IB case shows a different situation, where the "two mothers" provide complementary capabilities that the group takes advantage of. Although the University provides appropriate conditions, the research field can be better explored by complementing the infrastructure and other resources available at the university with the ones available at the FCI. The RGL was able to link the group to two organizations that support its activities in an interdependent way.

5. Conclusions

This work contributes to the understanding of the strategies that RGs use to operate, adapt, and thrive in an unstable policy and funding context. It is based on two case studies, plus two workshops held in Colombia. They all were meant to refine and test our propositions and showed to be highly valuable. The RGs, and particularly their RGLs, typically adapt to changing conditions and 'dance according to the tune', 'perform juggling acts', 'snuggle up to a tree with good branches', and strongly depend on their 'mother institution'. In addition, the RGLs play a key role in orienting and defining the RG strategy.

In the analyzed situations, we have documented elements associated with the propositions related to the strategies of the RGLs. As we have seen, RGLs and their networks play important roles to take advantage of STI policies and to combine several of them to continue their research. RGLs learn how to juggle research initiatives to deepen in the short term, with others that may be relevant in the future. Thanks to these strategies, research agendas are tailored to the available resources, but there are core lines that stay over the time.

The following table presents our observations regarding the evidence found about the propositions analyzed. It also shows, briefly, complementary points from the workshops, which present specific conditions and alternative situations. They open new research opportunities, not yet covered.

Table 1. RGL's strategies

Propositions	RGL's strategies		
	GIFTEX	IB	Workshops
"I dance according to the tune"	One core subject (cellulosic materials), adapted to the different calls for proposals	No single core subject is explicitly identified (hemosubstitutes is one among others)	To survive, it is necessary to respond to different calls for proposals and accept conditions and requirements.
"Performing juggling acts"	Mixing up and taking advantage of institutional, national, and international sources of funds to keep research initiatives and personnel active		A swarm intelligence is needed among the members of the group to take advantage of opportunities beyond the groups' direct reach

"If you snuggle up to a tree with good branches, you will have a blanket in its shade"	Personal networks of RGLs to take advantage of financing possibilities		High importance of the existence of several leaders within the group that actively work on networking. Not all groups have good "trees" to "lean-on".
	ie. One tree: Cornell	ie. One tree: Georgia Tech	
"Mother there is only one"	RGL appeals to its HI, UIS, which acts as the groups' 'mother'	RGL relies on two 'mothers': Uniandes and FCI	Major differences among the "mothers", as not all mothers are equally supportive.

The table shows different strategies that RGLs can use to keep their RGs functioning in the context of uncertainty. At a general level, a strategic definition can be done, such as choosing a core subject or maintaining several research venues. Also, networking can be strategically approached to tap different resources and capabilities. In the same vein, leadership can be diversely approached. While the two cases we studied are characterized by a central leadership, clearly exercised by the RGL, the workshops showed the usefulness of a "swarm intelligence", where multiple leaders cooperate to keep the RG's activities going on. It is worth noting that strategies are articulated by RGLs – like adapting the core subject to different calls for proposals and favoring several leaders within the group and networking. These coupled strategies became interdependent. Furthermore, the affiliation institution, depending on the support provided to research activities, can enhance the other strategies or be an obstacle to be overcome through them. Investing into the shaping of local institutional policies also become an extension to the RGs strategies and a way to better articulate them.

The following sections explain the lessons learned and the strategies (for RGLs and research institutions) and policy implications of our work.

5.1 Lessons learned

Science and technology policy and strategic management of research organizations, including universities, seeking global recognition through rankings is a growing phenomenon (McCormack et al., 2014), even in countries with non-market tradition (Parakhina et al., 2017). In emerging countries, little is known about RG's strategies, and specifically about their capacity to thrive in unstable contexts. Therefore, we used a bottom-up perspective to set the ground for a further representative survey. In the cases studied, we bring elements on how RGLs learn from "dancing" with other actors, including STI policy instruments, in a resilient and resourceful way, in the context of instability.

The strategies used by RG's members, RGLs and institutions are vital to harness policy instruments. These learnings on how to operate in the context of discrepancies among different policy instruments, poor coordination; incoherence between discourse and policy instruments; and financial and institutional instability, allow RGs to balance the dynamics between long-term research around a core subject and diversification and adaptation to opportunities for scientific collaboration and responses to calls for new knowledge and

innovative solution.

Using policy instruments implies the endogenization and local reconfiguration processes of STI policies, from the practices of the involved actors and sometimes the co-construction and adjustment to the policy instruments (Rip and Nederhof, 1985). The case study shows that this is also fully relevant for less advanced RGs, and the experience of RGs and the strategies documented here are useful for RGLs and science policy makers.

The case studies, the workshops and the synthesis of the results also show that the articulation of the four ideal-typical strategies at level of RGs and local institutions shapes a conceptual proposition for further investigation regarding how research groups navigate funding environments. The conceptual framework thus articulates research agenda, resources, people and institution. This can be expressed with more precise terms: investment on a core subject / adaptation to the opportunities; mixing up and taking advantage of different sources; swarm collective intelligence among the RG members and their personal networking; appeals to its (local, national and international) institutions which could acts as the groups' 'mother'. Further investigation of RGLs strategies need to explore these four strategic types.

The RGLs strategies have much to do with the subject they investigate. The shaping of the research agenda appeared to be a key element of their strategies. The other strategies have no meaning without this specific component. The research agenda is the place where the articulation is done and this has to do with the scientific and technical content, as this occurs for completely different situation like NASA missions (Vertesi, 2020). A dynamics balance is built between the continuity and capitalization on a core subject, and its diversification and adaptation to the opportunities.

Regarding the resources needed by research groups, the paper shows RGLs are taking advantage of a variety of sources (funds, people – among them students –, materials, and instruments), which are mixed, substituted the ones to others. This is consistent with what already shown through an ethnography lab study (Vinck, 1992). The variety of funding sources is not the only key component of the RGLs strategies. Science and technological development also depend on materials, instruments and people which sometimes can be found without going through funding institution. Among other, local investment in some instruments constitutes a resource allowing some continuity which funding does not offer.

This work also provides new insights into the role of people, their trajectories and networking activities. Didou-Aupetit & Gérard (2009) account for academic mobility in Latin American countries, and question repatriation policies that try to combat brain drain. These works raise the need to promote collaboration networks, which allow taking advantage of diasporas and collaborative relationships with scientific communities from other latitudes, largely constituted through postgraduate programs. The trajectories of researchers and the networks they constituted along their scientific education and career are key resources both regarding scientific content and a variety of resources. The cases studied also show the potential of policy instruments that allow taking advantage of diasporas. For example, in the case of IB it is clear how the RGL's trajectory is fundamental for the results of the RG. What starts as a co-author network becomes a co-invention network (Herrera et al, 2012). This is achieved by taking advantage of the diaspora originated 20 years before, when a doctoral student went to the American university where the RGL had finished his Ph D. In this sense, the training

abroad and the trajectories of RGLs influence the strategies of building networks[18].This is consistent with what other studies have shown (Feld & Kreimer, 2019a, 2019b). Furthermore, researchers' networking influence obtaining or not funding for their projects (Ebadi and Schiffauerova, 2015). Through our work, it became clear that learning how to use networks to combine different policy instruments is vital for RGs. The international linkages improve the group chances of accessing funding programs of distinct levels, as noted by some studies (Gaillard, Gaillard et al., 2014; Ordóñez-Matamoros, 2008). Also, the results of cooperation vary depending on the networking capabilities of the RGs involved (Ordóñez-Matamoros et al., 2020). Additionally, the availability of research equipment allows a symmetric cooperation with peers, that helps in the building a "protected space" (Vinck, 1992; Knorr-Cetina, 2001; Whitley, et al., 2018), different from the subordinated integration argued by Kreimer (2015) or the ones originated in the lack of resources (Robles-Belmont, 2016).

Finally, strategies regarding STI policy instruments also play a major role. RGLs appeal to and sometimes influence their local, national and international institutions which could acts as a 'mother', helping to pursue a fruitful research agenda, to fill some gaps, to overpass some policy instruments incoherence, etc. Research policy evaluation studies also highlight the role played by policy instruments in the creation of research networks (Lepori et al., 2008). Our work illustrates how RG capitalizes personal and informal networks and organizes itself to take advantage of policy instruments in unstable contexts. Sometimes, gaps emerge from the (local) implementation of STI policies. Our work then points to the key role local institution can have in supporting RGs on their journeys through the STI policy instruments and, if possible, provide mechanisms for filling them when necessary, or at least support them to facilitate the use of instruments external to the institution. This is also an opportunity for experimentation and learning for both groups (Chaminade and Padilla-Pérez, 2017) and HI (universities) (Vessuri, 1998; Van der Meulen and Rip, 1998). These strategies and challenges should be taken into account by policy agencies, involving the RGLs and considering their practices when defining policy instruments.

From a methodological point of view, the contribution of the paper concerns also the use of a novel blended approach. We blended 'episodic memory' (Reyes, 2008), metaphoric hypothesis, an abductive research method, and workshop validation, to gather more and better information than the one we would have collected through the two cases studied in a traditional way.

5.2 Limitations and future research
We analyze RGLs strategies in striving for continuing with RGs' activities in the Colombian STI system, where they need to take advantage of the scarce opportunities available while trying to maintain a core research agenda. We focus here on three limitations and perspectives.

This research is a first step which do not pretend to any generalization but draws four ideal-typical strategies forming a conceptual framework from which hypotheses could be generated. They need to be tested through a survey on a representative sample. The cases studies help to ground such potential survey. However, two cases studies cannot be representative. First, the RGs we studied are attached to universities ranked among the top ten of the country. Second, by focusing on two RGs working on nanotechnology and biotechnology, is not

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[18] A detailed explanation of the trajectory of the IPs of the GIFTEX RG can be found in Jaime, et al. (2016).

representative of the whole disciplinary spectrum of the Colombian research landscape. We cannot make claims that would apply to a larger group of RGs. Third, we focused on RGs highly dependent on substantial amounts of financial resources and expensive infrastructure for their operation. Finally, by studying university RGs only, we may have missed important aspects relevant to RGs affiliated with other types of institutions. However, to reduce the possible biases resulted, the workshops, involving a variety of RGLs and people experienced within scientific coucils and STI policies, allowed broadening the perspectives to learn from experiences with other institutions and disciplinary areas, allowing us to contrast and compare the cases and claims found in the two RGs studied. A further investigation grounding its research design on out resulting framework and on a representative sample for emerging countries would be welcome.

The study has identified four ideal-typical strategies. Even if this result already received a first validation through two workshops gathering experienced people in RG leadership and science policy, we do not pretend to be exhaustive in terms of the strategies that can be identified. Some lines of future research would therefore be to study a diversity of RGs from different institutional arrangements, disciplines, and countries to better analyze the identified strategies and try to identify additional strategies RGs follow in the context of bad policy coordination and funding instability characterizing emerging economies.

Finally, the paper has identified and documented strategies, but does not pretend to explain these strategies. A further study would be relevant for exploring the variables explaining these strategies, among others: the discipline, the research orientation (basic, applied, linked to industry, or to the needs of the State), the degree of dependence of equipment and technical devices, the trajectory of RGLs. Different variables may influence the type of strategy adopted. This would be relevant to study in future research endeavors.

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