Technological and social development projects as drivers for local innovation micro-ecosystems

Los proyectos de desarrollo tecnológico social como impulsores de micro ecosistemas de innovación local

Projetos de desenvolvimento tecnológico social como motores de microecossistemas locais de inovação

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Abstract

In Argentina, in 2013, the National Technological Scientific System incorporated an instrument, named Technological and Social Development Projects (PDTS, for its acronym in Spanish), to identify activities of technological development that had a social impact.

PDTS arise from a concrete demand from a social actor, formally requesting the intervention of researchers to develop a technological solution to a problem.

The objective of PDTS, the presence of actors and their relationships, create a space where the use and co-production of knowledge surpasses the scope of the original research objective, and can be extrapolated to other objects and issues. That co-produced knowledge adds value and innovation to the solution, characterizing it and making it unique with regards to local originality and identity. This process of co-producing knowledge builds skills in research and development groups, increasing the chance of generating new solutions to new problems, and creating a positive interaction spiral between university R+D and society. These interactions lead to “local innovation micro-ecosystems”.

This paper considers the distinctive characteristics of the PDTS and the knowledge co-production space and examines how the recurrence of these types of projects can generate “local innovation micro-ecosystems” that contribute to the country’s innovation capacity. This study concludes with an example of a “local innovation micro-ecosystem” in the area of Computer Forensics.

Key words: Technological Development; Innovation Ecosystems; Technological and Social Development Projects; Computer Forensics

Resumen

En Argentina, en 2013, el Sistema Científico Tecnológico Nacional incorporó un instrumento de reconocimiento de las actividades de desarrollo tecnológico con impacto social, denominado Proyecto de Desarrollo Tecnológico Social (PDTS).

El PDTS es la unidad de reconocimiento oficial de la actividad de desarrollo tecnológico con impacto social en Argentina. Un PDTS surge a partir de una demanda de un actor social que visualiza un problema a resolver y solicita la intervención de los investigadores para desarrollar una tecnología que le dé respuesta.

El objeto del PDTS, la concurrencia de sus actores y sus relaciones constituyen un espacio de utilización y coproducción de conocimiento donde ese nuevo conocimiento va más allá del objeto de investigación, se hace general y extrapolable a otros objetos y problemáticas. Ese conocimiento coproducido es el que agrega valor e innovación a la solución, la caracteriza, la hace inédita en términos de originalidad local y le da una identidad local. Ese proceso de coproducción de conocimiento genera capacidades en los grupos de investigación y desarrollo, potencia las posibilidades de generación de nuevas soluciones a problemáticas novedosas, y provoca un espiral positivo de interacciones entre la I+D universitaria y la sociedad. Estas interacciones dan lugar a los que en este ensayo se denominan “micro ecosistemas de innovación local”.

En este ensayo se consideran las características distintivas de los PDTS y del espacio de coproducción de conocimiento y se analiza en detalle cómo la recurrencia de este tipo de proyectos puede generar “micro ecosistemas de innovación local” que contribuyen a la capacidad de innovación del país, cumpliendo con el rol de instrumento de política científico-tecnológica con que fueron creados. El presente estudio culmina con la presentación, a modo de ejemplo, el caso de un “micro ecosistema de innovación local” en el área temática de la Informática Forense.

Palabras clave: Desarrollo Tecnológico; Ecosistemas de innovación; Proyectos de Desarrollo Tecnológico Social; Informática Forense

Resumo

Na Argentina, em 2013, o Sistema Nacional Científico e Tecnológico incorporou um instrumento para o reconhecimento das atividades de desenvolvimento tecnológico com impacto social, denominado Projeto de Desenvolvimento Tecnológico Social (PDTS).

O PDTS é a unidade oficial de reconhecimento da atividade de desenvolvimento tecnológico com impacto social na Argentina. Um PDTS surge de uma demanda de um ator social que visualiza um problema a ser resolvido e solicita a intervenção de pesquisadores para desenvolver uma tecnologia que responda a ele.

O objeto do PDTS, a confluência de seus atores e suas relações constituem um espaço de uso e coprodução de conhecimento onde esse novo conhecimento ultrapassa o objeto de investigação, generaliza-se e pode ser extrapolado para outros objetos e problemas. Este conhecimento coproduzido é o que acrescenta valor e inovação à solução, caracteriza-a, torna-a inédita em termos de originalidade local e confere-lhe uma identidade local. Esse processo de coprodução de conhecimento gera capacidades em grupos de pesquisa e desenvolvimento, aumenta as possibilidades de gerar novas soluções para problemas novos e provoca uma espiral positiva de interações entre P&D universitário e sociedade. Essas interações dão origem ao que neste ensaio chamamos de "microecossistemas locais de inovação".

Este ensaio considera as características distintivas do PDTS e do espaço de coprodução de conhecimento e analisa detalhadamente como a recorrência desse tipo de projeto pode gerar "microecossistemas locais de inovação" que contribuem para a capacidade de inovação do país. -instrumento de política tecnológica com o qual foram criados. O presente estudo culmina com a apresentação, a título exemplificativo, do caso de um "micro-ecossistema local de inovação" na área disciplinar de Perícia Computacional.

Palavras-chave: Desenvolvimento Tecnológico; Ecossistemas de inovação; Projetos de Desenvolvimento Tecnológico Social; Computação forense

1. INTRODUCTION

In Argentina, in 2013, the National Technological Scientific System incorporated an instrument, named Technological and Social Development Projects (PDTS, for its acronym in Spanish), to identify activities of technological development that had a social impact. Two official documents, named "Document I" and "Document II" of the Advisory Commission on the Evaluation of Scientific and Technological Personnel, provide the framework of criteria and details on the definition of this instrument [1,2].

Since then, the PDTS have become the official unit of recognition for technological development activities with a social impact in Argentina. PDTS arise from a concrete demand from a social actor that visualizes an issue that needs to be solved and formally requests the intervention of researchers to develop the technology to do so. This activity implies creating cognitive innovations that need new technological knowledge, which is transferred to society to solve a practical issue or need.

PDTS are really an instrument with a double goal, one in the scientific-technological area, and another in scientific-technological policies. On the one hand, PDTS are instruments that seek to solve the frequently mentioned "recognition issue" with regards to technological development activities with a social impact in the SCTN, encouraging it. On the other hand, PDTS become public policy instruments to promote a specific type of research and technological development activities, that is, the ones that produce cognitive innovations with a social impact. Both purposes direct the research and development activity towards achieving an innovation with a systemic character as a key ingredient for the comprehensive development of the country.

An important aspect to highlight regarding the instrument and its dual purpose is that of Law 25467 on Science, Technology and Innovation. It establishes that the evaluation of scientific and technological activities constitutes a permanent obligation of the Government; having the purpose to assess the quality of the work of scientists and technologists, allocate resources for science and technology and estimate the link between these activities and the social objectives. Despite the obligation established by law, the defined regulations and instruments have not allowed progress in a key aspect: the ex-post evaluation of PDTS and of the scientific-technological researchers involved in them with uniform criteria. From this perspective, PDTS could be considered an "incomplete instrument" of the National Scientific and Technological System [3]. The existence of uniform mechanisms, or at least criteria or recommendations, for ex-post evaluation of the instrument itself, would strengthen the public policy that inspires it. This lack of evaluation mechanisms or criteria ends up discouraging the adoption of the instrument by researchers and laboratories, since they prefer to remain in a "traditional" evaluation system, with known guidelines and mechanisms, which allow them to develop their career with greater predictability. Therefore, it is urgent to develop an ex-post evaluative technology proposal that completes this valuable instrument of public policy and enhances it [4]. This is the final objective of the first author's thesis and within its framework, this article is developed.

2. TECHNOLOGICAL AND SOCIAL DEVELOPMENT PROJECTS (PDTS)

PDTS are structured activities based on projects that, among other characteristics:

a) make use of scientific and technological knowledge belonging to one or more disciplines;
b) involve elements such as theoretical precedents, methodologies and techniques, specific information, phases, technical and financial resources, expertise, ethical and social legitimacy, evaluation criteria for the activity,

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and others that are explicit enough and ordered in a way that allows for comprehension of project goals and objectives, reaching the expected cognitive advancement, having a feasible performance, and showing indicators to evaluate management, advancement, and achievements;

c) have the goal of solving practical issues or needs, that is, those that not only arise from scientific curiosity, advancing on the discipline's knowledge or solving theoretical questions, but that emerge from social, political, economic or market needs;

d) are oriented towards solving a problem—whether a technology, regulating frame, an intervention in society, a prospective technology or a process or product evaluation—that can be applicable or replicable for a specific case;

e) have a well-defined goal that must be justified by a national, regional or local interest;

f) need to provide an answer to issues and/or needs, incorporating cognitive innovations, that is, it is not limited to applying procedures, routines, methodologies, findings, knowledge assertions, etc., that are codified and normalized in the knowledge stock of the project disciplines, even when these elements are part of it;

g) need to identify one or more public or private organizations that specifically demand a solution to the issue or are potential adopters of the obtained result;

Additionally, PDTS must satisfy four fundamental criteria. Namely:

Criterion 1: Novelty or Originality. In general, any research and development project imply creating new knowledge on the phenomena and/or solutions to technological challenges. Cognitive novelty is a main characteristic of the scientific-technological activity. However, this assertion must be nuanced in light of the key PDTS characteristic, that is, adopting a "local" technological development. In PDTS, the concept of knowledge novelty is redefined, adopting a contextualized meaning that implies full attention to local conditions. Then, the question of originality needs to be understood in the sense of "local novelty".

Criterion 2: Relevance. The criterion of relevance has to do with the objectives of the public policy, the need or urgency or the issue to be solved by means of the generated knowledge or technological innovation that is implemented. Relevance is a concept that is strictly political in the wider sense, and therefore it does not refer to

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intrinsic characteristics of the projects, but to their goals and objectives. Relevance is linked to the usefulness or impact of the project results.

Criterion 3: Pertinence. Pertinence determines whether the research strategy, the proposed methodology, and the expected results are adequate to solve the issue that was identified or for the concrete use that was expected for the project. The analysis of pertinence is similar to the project ability to reach the expected results.

Criterion 4: Demand. A key condition for PDTS is the existence of a requesting agent and an adopting agent for the results of the project. The existence of these agents, that can be the same person, are proof that the project results are of interest to society and not merely a means of satisfying the interests of advancing the discipline of the research community involved.

2.1. PDTS Characterization

For Naidorf, Vasen y Alonso [5], PDTS are research projects that seek to promote the development of technologies associated with solving a specific social issue or taking advantage of a strategic market opportunity, creating a closer link with potential users of that knowledge and the research process and introducing evaluation methods that separate it from other existing research projects [5].

Through their studies of PDTS, Naidorf, Vasen y Alonso [5] introduce the concept of "responsible innovation", considered as a key perspective in the "science with and for society" component of the European Union's "Horizon 2020" financing program. Following this perspective, knowledge creation should be anticipated and aimed at producing positive impacts, and these need to be measured not only by market mechanisms. This means taking into account, from the beginning, a set of questions (or "dimensions") that provide responsible guidance of the innovation process. Following this line of thought, Stilgoe, Owen, and Macnaghten proposed the dimensions of anticipation, inclusion, reflexivity, and reaction capacity [6]. The goal of these proposals is to accompany the development of innovation projects so that they show the interests and values of a wide set of actors. PDTS, as public policy instruments, share these social goals to guide their objectives and create scientific knowledge that solves—or contributes to—a social issue. Indeed, when including new concepts such as "the adopting institution" or "the requesting institution," PDTS seek to incorporate potential knowledge users that are key actors in the production process. That is why PDTS can be considered an innovative answer to the need to aim public policies in science and technology to social goals.

One of the ways of dealing with PDTS as an object of study demands characterizing it, identifying the actors, their roles and interrelations as constitutive elements of a "knowledge co-production" space. The concept of co-producing knowledge is a key characteristic of PDTS, as they determine the interaction dynamics that take place in a space where solutions are proposed for social requests. The actors and their interrelations participate in a framework where knowledge, issues, goals, tension, and external constraints flow in order to build this socio-technical-scientific network to innovate in this specific topic.

The analysis of knowledge production paradigms, such as the classic works by Gibbons et al, describe a dichotomy between a "Mode 1" and a "Mode 2" and suggest that none of these "modes" rigorously account for the characterization of their knowledge co-production space in which PDTS are developed [7]. As a consequence, a detailed characterization of them is needed. This characterization adopts a classic concepts as a baseline, such as Stokes' "Pasteur's Quadrant" to describe how two key interests converge: creating new knowledge and applying it to solve relevant social issues [8].

This characterization also includes technical aspects of the PDTS themselves and their context. In this way, PDTS are always affected by the local or peripheric reality where the development of science and the production of technology take place. In the local context, certain aspects become relevant as they tend to fulfill the more general PDTS goals, including training researchers for innovation, and based on this, creating and consolidating a local culture of systemic innovation. In this sense, PDTS are constituted in a SCTN project to facilitate innovation and consolidate an authentic National System for Innovation.

3. THE KNOWLEDGE CO-PRODUCTION SPACE. ACTORS AND RELATIONSHIPS.

The current regulation of Ministry of Science, Technology and Productive Innovation [1, 2] states that the following actors can intervene in PDTS[1]:

- Executing institutions: these are scientific-technological institutions that participate in carrying out project activities. For PDTS to exist, it is essential that at least one of these institutions participates.

1 Promoting units may also intervene.

- Executing Units: these are the research centers that belong to the executing institutions involved in the project. For PDTS to exist, at least one of these Units needs to participate.
- Funding Entities: these are entities that contribute to financing the PDTS. Both external entities as executors, as well as the Executing Institutions themselves are included and can be funders of the PDTS. For PDTS to exist, at least one Funding Entity needs to participate.
- Requesting Entities: these are the private or managing national, provincial or local government entities that act as external requesting entities for technologies developed in the context of a PDTS. They manifest the issue to be solved and expressly request a solution for it. For PDTS to exist, it is not essential that a Requesting Entity participates, and it is not common for more than one to be involved.
- Adopting Entities: these are the beneficiaries or users who are able to apply the results developed in the framework of the PDTS. For PDTS to exist, it is essential for an Adopting Entity to participate. An Adopting Entity can participate at the same time as a Requesting Entity when it expresses the problem to be solved and explicitly requests a solution for it.

Briefly, in PDTS there are at least: a) Executing Units: Research Centers that rely on Executing Institutions, develop project activities, and produce the expected technology; b) Requesting Entities: they pose the problem to be solved and request a technological solution from the Executing Units; c) Adopting Entities: they benefit from the results of applying the developed technology; and d) Funding Entities: they allow for the necessary resources and supplies to develop the project. These actors share a common goal; they solve a practical issue by developing technology. In PDTS, the production of new technological-scientific knowledge is not the end of the project, it is a means to solving a problem. In this way, PDTS involve producing scientific-technological knowledge to solve a real and urgent social issue.

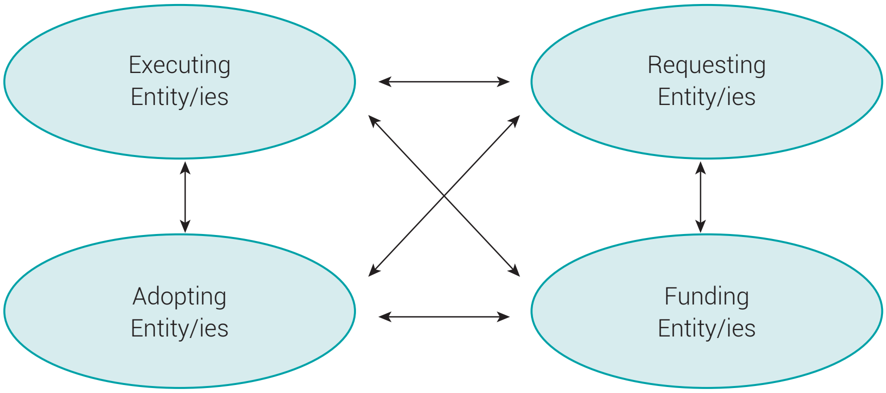


Figure 1. Actors and relationships in a PDTS
Source: own work

Different from "basic or pure research" projects, which are fundamentally directed towards understanding nature and society without necessarily having a possible practical application, and are included by Stokes [8] in the so-called "Bohr Quadrant", PDTS are located within the "Pasteur Quadrant", which is only for "applied research inspired on basic research." In this quadrant, Stokes located a "research style" that produces scientific knowledge and strategic solutions by means of research directed at issues coming from an external environment [8]. In other words, in the "Pasteur Quadrant," available knowledge is fully used to create new knowledge. That is why deep understanding of available knowledge is essential to use it correctly in order to produce cognitive innovations and develop new technologies. To that end, research needs to be developed in a "basic style," which implies rigorous consideration, interpretation, and use of available knowledge [9].

According to Langford and Langford, the so-called "Knowledge Economy" has generated a context where the ability to assemble and exploit knowledge has become a key factor for company competitiveness and compliance with the country's mission, acknowledging that no State company or institution can produce or control all the knowledge it needs to work [10]. This leads to a new "mode" of producing knowledge, directed at solving issues that demand inherently transdisciplinary approaches and are much more dependent on the interaction of the actors involved. In this context, Gibbons et al propose a "Mode 2" of knowledge production, which complements what they call "Mode 1" of knowledge production, characterized as "traditional" and created within the "context of a discipline" with fundamentally "cognitive" ends [7].

In this "Mode 2," knowledge is generated in large social and economic transdisciplinary contexts, and as a result of a wider range of considerations; it needs to be useful to someone, whether an industry, government or society. Knowledge production is developed in an environment of continuous negotiation and is not attained if the interests of the different actors are not included. The teams dedicated to solving the issues change in time, following the evolutions of the arising demands. Flexibility and response time are essential factors. There are a series of actors who come together to solve specific issues.

In "Mode 2," research institutions are closely associated or linked with the demand, which may come from the private sector, government or non-government organizations. This opens up the possibility of establishing a "Triple Helix" type of interaction, studied by Etzkowitz (11). In the "Triple Helix" model, innovation takes place in the area where subsystems from universities, industries based on knowledge, and governments meet, and they become the three blades of the helix. Innovation is driven by the relationships and interactions among two or more of these action subsystems. Van den Besselaar, in his dissertation "Is S&T policy research transdisciplinary?" given in New York in January 1998 [12], considered that, at that time, in terms of research organization, many new links between research institutions, companies, and government institutions were emerging, which, in cognitive terms, would mean the emergence of a new "research style." That style has been schematically described as "transdisciplinary and motivated by extra-cognitive interests" and it has been considered complimentary to the style characterized as "monodisciplinary and motivated by essentially cognitive interests." This new "research style," typical of the "Pasteur Quadrant" and named "Mode 2" by Gibbons et al is, in general terms, compatible with the one proposed by PDTS.

In this characterization, the "issue to be solved" is the first object of shared knowledge among the actors, and it arises together with PDTS formulation. It is essential to build this issue among the actors, both in formulation and conceptualization, and to consensually define the project goal, its reach and its restrictions, with regards to the expected solution. Relationships that have trust and generosity in the shared use of the knowledge are needed to specify the problem, formulate the project, and develop the solution. Merging the actors' knowledge is a seed that, starting from that shared knowledge and with later contributions by each intervening actor, can produce new knowledge and develop technology. Genuine contributions to the common knowledge base and research by each and every one of the actors constitutes the base for the PDTS development and goal achievement.

Unlike other projects or research, it is not only scientific-technological institutions who produce knowledge: in PDTS, scientific-technological institutions inevitably need contributions from the rest of the actors to produce knowledge in the shape of technology to solve issues. To achieve the goals, new knowledge in PDTS is necessarily a result of co-production among intervening actors. In this way, the issue itself, the project goal, the actors, and their interrelationships make up the "knowledge co-production space" that is key in PDTS development. As suggested by the schemes, included as figures, the starting knowledge of a PDTS comes from the intersection of the actors' knowledge with regards to the issue. Formulating the issue comes from considering part of that intersection, which could be described as the "minimum expression of starting knowledge" or, more specifically, the "germinal knowledge" of a PDTS.

Technological development, and ultimately the PDTS, is the process by which a technical solution is reached to answer the issue. This solution needs to follow formal requirements that determine the PDTS condition for the project, especially the rigorous use and deep harnessing of existing knowledge and the generation of a concrete cognitive advancement.

In the "co-production" process, intervening actors contribute their own knowledge to the articulation process and exploitation of consolidated knowledge to create a new one; not only on the particular research object but, given the research style from which it originates, one that can be extrapolated to other objects and issues. Each actor's individual knowledge grows as they incorporate and merge knowledge that comes from others. The solutions in advanced and finished PDTS ultimately have a much wider cognitive reach than those initially available in the PDTS. The "final knowledge" created in PDTS is much greater than the "germinal knowledge" that was available at formulation. The knowledge produced adds value to the solution, characterizes it, makes it unique in terms of local originality, and distinguishes it from a "professional" or "industrial" solution. That knowledge, when applied, exceeds the PDTS actors and reaches others and areas that do not belong to the PDTS, creating a particular social impact in the Adopting Entities and more.

To summarize, the object of study, the actors, and their interrelation constitute a knowledge co-production space and process that is characteristic of PDTS, different from common research as described in the "Bohr Quadrant." Besides, the fact that knowledge is produced as a means and not as an end makes co-produced knowledge not the main or, much least, the only variable to be considered in evaluation. In PDTS, knowledge is produced to create social impact that represents the ultimate PDTS goal and meaning. Knowledge production is a necessary condition, but it is not enough to value PDTS results. The produced cognitive innovations need to have an impact by means of a technology that satisfies the PDTS goals. In this way, the PDTS contributes, in general terms, to the innovation process, creating new knowledge and putting it into practice.

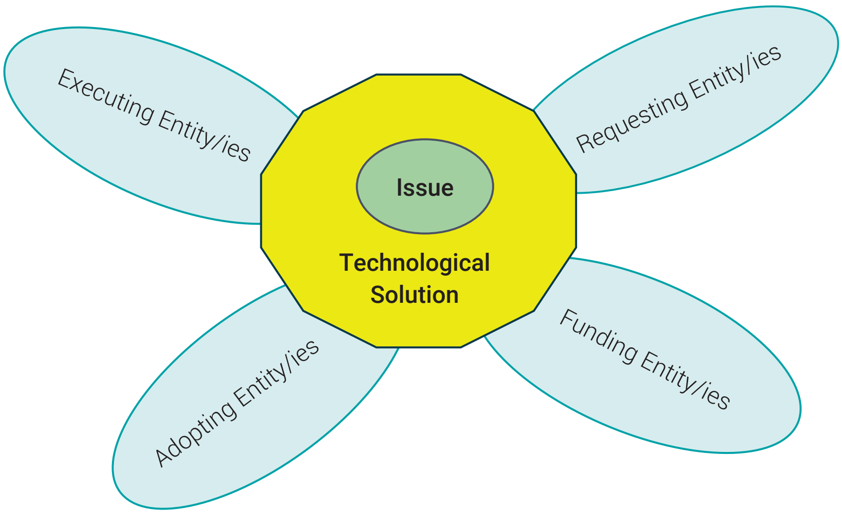


Figure 2. Solution as co-produced knowledge in PDTS
Source: own work

4. LOCAL INNOVATION MICRO-ECOSYSTEMS

The concept of "innovation ecosystem" originated in the field of biology and has been adopted by many authors, although its introduction is attributed to James Moore in his article "Predators and Prey: a New Ecology of Competition," published in the Harvard Business Review Magazine [13]. For Andreu, the term ecosystem refers to a community of independent organisms that share the same habitat [14]. Their interactions and exchanges of matter and energy result in the balance of the ecosystem. For Marrs, an ecosystem is a non-lineal complex adaptive system that is constantly adapting to the changes in its surroundings, which often occur unexpectedly, and it can only be considered as a whole, and not as something fragmentary, because each part of the system depends on and has a functional effect on the others [15]. An ecosystem is a complex gathering of relationships that change dynamically.

The concept of an "innovation ecosystem" refers to a habitat where efforts, perspectives, and potentialities are gathered from the different organizations that are part of it to exceed its limits and, by means of collaboration, transform knowledge into innovation. Innovation is the main goal, the organizing axis, the driving force, and the expected result. Talmar et al. propose that an ecosystem is characterized by a goal at the system level that has the shape of a coherent solution directed at the requester [16]. The origin of its conception, named the Ecosystem Pie Model (EPM), involves an

"Ecosystem Value Proposal" (EVP), that is, a solution developed for the ecosystem to satisfy a (supposed) need and/or wish from the requester. Therefore, the whole innovation ecosystem moves after a specified issue or request to which it seeks to give an effective solution. These authors also claim that value in ecosystems is created collaboratively in the supply (or development) actors' interface and the demand actors' interface. The requesters also contribute to and generate tradeable value, such as specific data or knowledge, that the other actors in the ecosystem can use to provide a greater value to other projects within the same or outside the ecosystem. Gobble adds that innovation ecosystems are dynamic communities with a purpose, with complex and interconnected relationships based on collaboration, trust, and co-creation of value and that they are specialized in the exploitation of a shared set of technologies or complementary skills [17]. In addition, when they have reached maturity, innovation ecosystems are productive, that is, they translate knowledge into a larger value and are resistant to interruptions [18].

Granstrand and Holgersson presented a systematic revision of 120 publications on innovation ecosystems and their key references, identifying 21 definitions [19]. They proposed that "an innovation ecosystem is a developing set of actors, activities, and artifacts, institutions and relationships, including complementary and substitution relationships, which are important for the innovative performance of an actor or a group or actors (population)." In that revision, the only common component to the 21 definitions are the actors. The second common component is collaboration or complementarity, which appears in 16 definitions, in contrast with competence or substitution, which only appear in 6 definitions. The third common component are the activities, which appear in 15 definitions. The component of artifact, which includes, for example, products and technologies, appears only in about half of the definitions.

To summarize, the definitions for an innovation ecosystem that were more frequently used emphasize collaboration, complementarity, and actors rather than competence, substitution, and artifacts. This is an important point because it characterizes the innovation ecosystem, fundamentally by collaboration among the actors. This does not deny competence because it exists just as in biological ecosystems. In both cases, the relationships between these actors guarantee the balance of the system, a sort of tacit mechanism that favors survival or a "life pact" by all the members involved.

Both cooperation and competence relationships contribute to creating value. Cooperation particularly allows exploiting synergies and using them, moving up in the creation of value. These dynamic relationships guarantee the co-evolutive nature of the ecosystem and each one of its actors. The characteristic named "adaptive capacity" in an ecosystem describes the fact that individual and collective behavior change and the actors organize and rearrange themselves according to the events that take place in the environment or habitat in order to survive or evolve individually and collectively. What happens to one member of the ecosystem has an effect on the others. When one of the members is innovative, the innovation somehow reaches everyone in the system, and it can be said then that "the ecosystem" is innovative. These innovations have, at the same time, an impact outside the ecosystem.

An important aspect to highlight is that all the authors, and especially Granstrand and Holgersson, take as a starting point the innovation seen as the result of a process with two defining characteristics: a) a degree of novelty or a change introduced; and b) the degree of usefulness or success in applying something new. Within this framework, the concept of "new" could mean new to the world, to a nation, to an organization, etc. In the specific case of PDTS, a necessary condition is that they comply with a local novelty or originality criterion: that is, being limited to a certain area. This criterion can also be applied to the innovation produced in innovation ecosystems: the innovation expectations and production in the ecosystem shall then be limited to a space or local area (city, province, country). This leads to "innovation micro-ecosystems," which are generally focused on a certain issue or area.

In the first place, local innovation micro-ecosystems, that is, those innovation ecosystems focused on a certain issue or area with local reach, are dynamic communities with a purpose, complex and interconnected relationships based on collaboration, trust, and co-creation of value, and they specialize in exploiting a set of shared technologies or complementary abilities. They gather efforts, perspectives, and potentialities from the different actors involved to exceed their personal limits and, by means of their relationships, fundamentally cooperation, transform innovation knowledge.

The Ecosystem Value Proposal (EVP) emerges from the solutions developed by the local innovation micro-ecosystems themselves to satisfy the needs of the requesters who are close to the issue that the micro-ecosystem revolves around, its context, habitat or city. Innovation is at the center of the organization or shaping of the local innovation micro-ecosystem. It is the main goal and driver, directed at developing effective solutions to the issues raised by local requesters. Context conditions make the local innovation micro-ecosystem, and each one of its actors, organize and reshape themselves to survive, evolve, and grow individually and as a system to answer the demands, solve issues, and put new ideas into practice.

In a local innovation micro-ecosystem, the relationships among the actors, mainly cooperation or complementarity, and the activities developed, build the basis for innovation, and for this to take place, there is a fundamental catalytic aspect; trust among the actors. Trust facilitates relationships, promotes a shared meaning and vision, and guarantees the successful development of the activities. Without trust among the actors, the knowledge and technology that they could contribute will not generate an authentic innovation micro-ecosystem. That trust must be built on a daily basis among all the actors, and this is part of the evolution process of the local innovation micro-ecosystem. Steinbruch, Nascimento and Menezes consider that trust among the actors is the result of the interconnection of three dimensions: 1) capacity; 2) benevolence; and 3) integrity [20]. Moreover, they analyzed four dimensions for innovation micro-ecosystem: (a) network collaboration; (b) interdependency; (c) co-creation of value; and (d) innovation goals, concluding that trust contributes to the development of these dimensions. Finally, they warned about the need to tend to these four dimensions of trust together and simultaneously because, individually, they are not enough to build trust in innovation ecosystems.

Forming and consolidating local innovation micro-ecosystem takes years (Silicon Valley took decades) and shared meaning, vision, and values, which do not imply homogeneity, are essential aspects that must also be built together to help the evolutionary development of the micro-ecosystem during the whole process. When shared trust, meaning, vision, and values are set as intangible components of the micro-ecosystem, respecting diversity and differences among the actors, we can talk about a "culture of local innovation" that characterizes the micro-ecosystem. This culture is felt within the innovation micro-ecosystem, reaching all the actors, relationships, and activities, and at the same time, acquires an identity stamp.

In PDTS, the relationships among the actors in the development of these projects are also created collaboratively, co-producing knowledge and innovation. The co-produced knowledge adds value to the solution, characterizes it, and makes it unique in terms of local originality. The recurrence in the development of PDTS among different actors leads to a positive interaction and relationship spiral that strengthens the actors' capacities, leading to local innovation micro-ecosystems. These local innovation micro-ecosystems grow, incorporate researchers, capitalize on knowledge, involving new actors and developing new capacities in a framework of trust and "innovation culture". They also mature and define shared meaning, vision, and values, constantly creating innovation.

Finally, it is important to mention that, in general terms, the coordinated action of these micro-ecosystems in their dialogue and mutual cooperation, together with the support of public ad hoc policies, contribute to the development of innovation systems with a wide reach. The articulated and coordinated sum of local innovation micro-ecosystems contributes, in the long run, to boosting a country's innovation capacity and, with it, the development and strengthening of its National System for Innovation. At the same time, recurrence in the development of a PDTS in a certain field, with local reach, of a set of actors that interact and grow, can ultimately become a driving force for local innovation micro-ecosystems that contribute to the country's innovation capacity and, when articulated with others, strengthen the National System for Innovation. The PDTS can then reach its goal as a scientific-technological policy instrument.

5. CASE STUDY

So far, we have proposed the hypothesis that recurrence in PDTS development in a certain field, with local reach, with a set of actors that interact and grow, can ultimately create a local innovation micro-ecosystem that contributes to national and regional innovation capacity. With the goal of providing empirical support, the hypothesis is presented below in the case of the School of Engineering at Universidad FASTA and its Research and Development Group for Computer Forensics, which is a well-known promoter of the Research and Technology Laboratory on Computer Forensics (InFo-Lab), located in the city of Mar del Plata, Argentina.

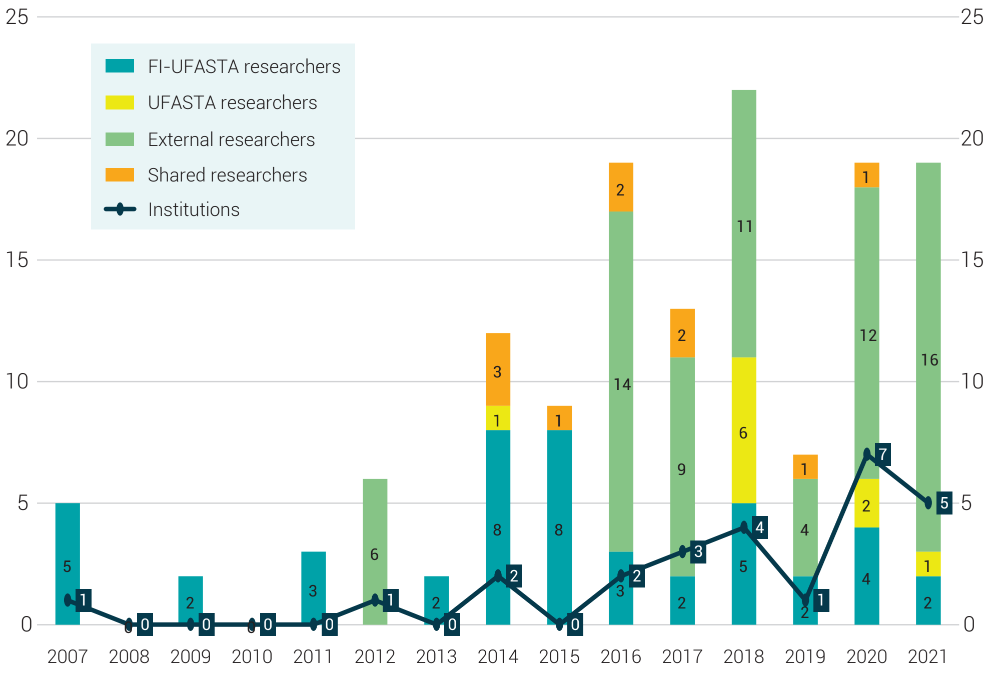
The Research and Development Group on Computer Forensics from the School of Engineering at Universidad FASTA, hereinbelow referred to as the "Research Group," has been working since 2007, together with the university mission of "...finding answers at the university for the needs of the Argentine people and the perspectives of the country's human, production, social, and sustainable development, taking into account the needs of the areas it can reach and the regional integration processes" This Research Group is formed by researchers from different disciplines and institutions who have been performing research and developing technological solutions for 15 years in the field of Computer Forensics. As a consequence of the interaction between the Research Group and the Public Prosecution Office in the Province of Buenos Aires, in May 2014 an interinstitutional agreement was signed by Universidad FASTA, the Buenos Aires Prosecution Office, and the Municipality of General Pueyrredón to form a Research and Technology Development Laboratory on Computer Forensics (InFo-Lab). This laboratory, head office for the Research Group, gathers in the city of Mar del Plata a multidisciplinary team of technology-scientific researchers, who are highly professional and qualified, with the goal of advising and providing technological solutions to the Court of Justice in the field of applied forensic sciences.

The Research Group decided, from the beginning, to emphasize applied research and the development of technology based on projects that are perfectly adjusted to the conceptual definition and then the formal one for PDTS. It started working on its own research projects and, after a short period of time, began answering the requests of several institutions from the School of Engineering. Moreover, due to the requests and needs, it incorporated other researchers and academic institutions to the projects, which strengthened its production capacity. All in all, from the year 2014, it has been the formal link between Universidad FASTA and the Prosecution Office (General Prosecution Office for the Supreme Court of Justice) in the Province of Buenos Aires and the Municipality of General Pueyrredon, for the Laboratory to develop a Computer Forensics local innovation micro-ecosystem with this interinstitutional proposal as a basis.

Every year, different demands arrive at InFo-Lab, which are formalized and solved by means of PDTS. In that way, new institutions joined the micro-ecosystem, either as promoting, requesting, adopting or co-executing entities. Researchers from the School of Engineering joined these new projects, as well as researchers from other academic units from Universidad FASTA or from other universities, and of course, from the requesting and adopting entities involved in the PDTS. In this way, a Computer Forensics local innovation micro-ecosystem was formed and shaped.

Interinstitutional relationships of trust and co-production of knowledge were established and strengthened among the different actors in the micro-ecosystem, whether they shared a project or not, given that their knowledge and experiences were transformed into common capital and boosted the development potential of new technological solutions for each and every one of the actors. InFo-Lab acts, up to some point, as the articulator of the actions and the manager of the relationships and projects. Considering the number of institutions and researchers in the micro-ecosystem as indicators of its dimension, we can appreciate its growth in time. The figures below show how institutions joined the system, always linked to PDTS that were formulated together, and how the number of researchers involved grew. These are the carriers of knowledge who represent the capacity of their respective institutions to develop technology and solutions.

Graphic 1 shows the yearly increase in the number of researchers involved in the PDTS at the center of the micro-ecosystem, categorized into: researchers from the School of Engineering from Universidad FASTA (FI-UFASTA researchers), other Schools at the same university (UFASTA researchers), other micro-ecosystem institutions that do not belong to UFASTA (EXTERNAL researchers), and the ones shared by more than one institution in the micro-ecosystem (shared researchers). In the same graphic, the dotted line shows the number of institutions that joined the micro-ecosystem yearly. Particularly in the years 2007 and 2011, the only institution involved was the School of Engineering at Universidad FASTA with 5, 7, and 10 researchers in the years 2007, 2009 and 2011 respectively. In 2012, a second institution joined the ecosystem, supplying 6 new researchers. In 2014, the first researchers from another academic unit at Universidad FASTA joined and also 3 researchers who worked at two sites. From 2016 at least one person joined the institution yearly: in 2020, 7 new institutions, and 5 in 2021. In this way, the number of affected researchers who are external to UFASTA has increased.



Graphic 1. Researchers and institutions joining the Computer Forensics micro-ecosystem yearly

Source: Mónica Pascual, 2022

Graphic 2 shows the evolution of the innovation micro-ecosystem in terms of the number of researchers. The quantity of researchers in the micro-ecosystem is represented yearly between 2007 and 2021, reaching 138 in 2021, from which only 46 (26,7%) are exclusively from the School of Engineering at UFASTA, 66 (38,4%) have total or partial dependency at Universidad FASTA, and 72 (52,2%) are exclusively researchers from other institutions in the micro-ecosystem.

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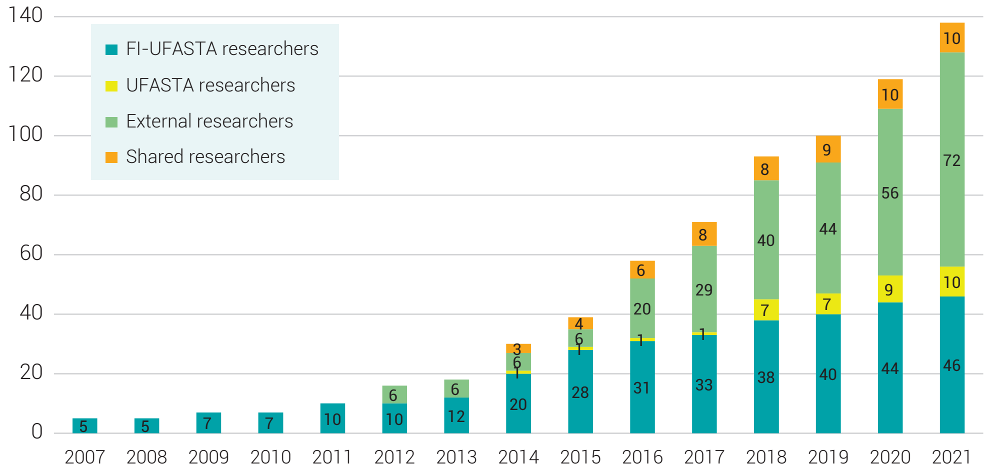
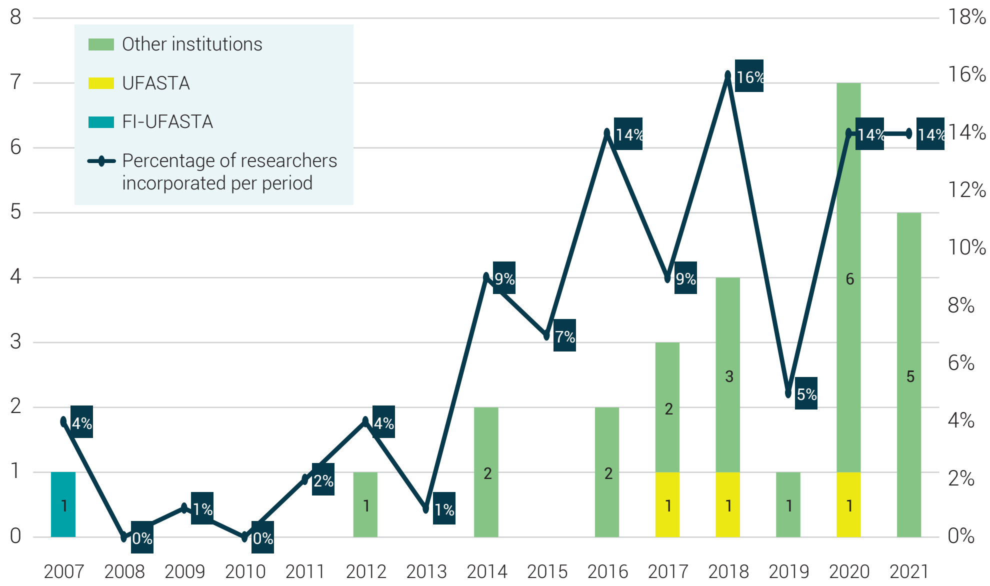


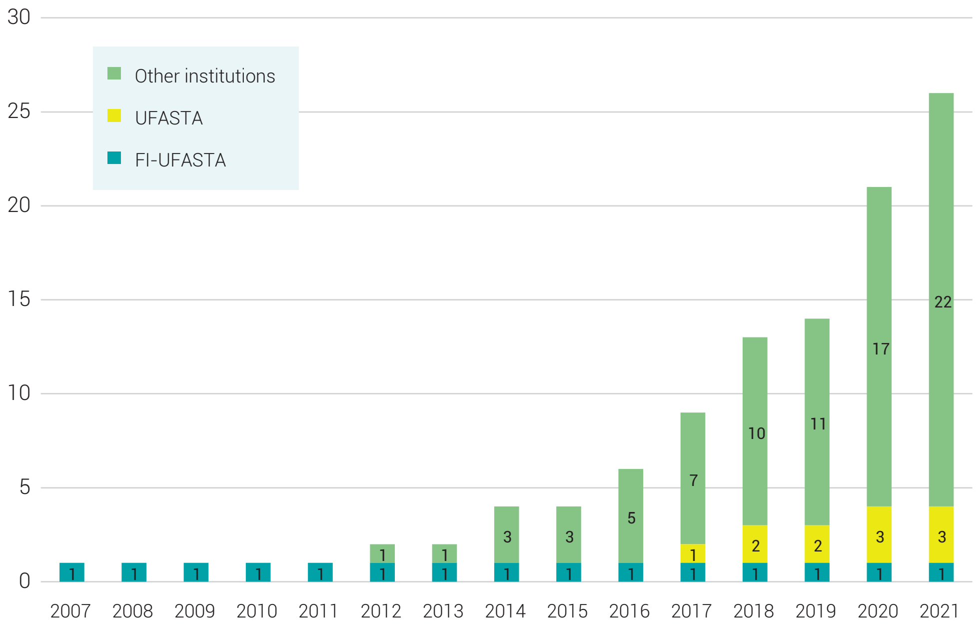
Graphic 2. Evolution in the number of researchers in the Computer Forensics micro-ecosystem
Source: Mónica Pascual, 2022

Graphic 3 shows the yearly increase of participating institutions in the PDTS originating in the micro-ecosystem, (different from other schools at Universidad UFASTA itself) and other institutions in the micro-ecosystem different from UFASTA. In the same graphic, the dotted line shows the total percentage of researchers that joined the micro-ecosystem yearly in relation to the final value (128 in 2021).



Graphic 3. Institutions incorporated yearly to the Computer Forensics micro-ecosystem
Source: Mónica Pascual, 2022

Graphic 4 shows the evolution in the number of institutions in the micro-ecosystem. The number of institutions that joined the micro-ecosystem is presented yearly between 2007 and 2021, reaching 26 institutions[2] in 2021.



Graphic 4. Evolution of the number of institutions in the micro-ecosystem of Computer Forensics

Source: Mónica Pascual, 2022

In this case study, the development of a local innovation micro-ecosystem can be seen clearly in the field of Computer Forensics based on the recurrence of the PDTS development in a certain knowledge niche, located in a research and development group that has a strong history of service to the community, originating from the

2 UFASTA (School of Engineering), UNIANDES (School of Engineering), Public Prosecution Office of the Province of Buenos Aires, Municipality of General Pueyrredón (Local government), UTN (Regional Delta School), UNIANDES (Law School), UNNOBA (Technology School), Public Ministry of the Autonomous City of Buenos Aires, UFASTA (Law and Social Sciences School), UNMdP (School of Engineering), Municipality of General Pueyrredón (Ombudsman Office), UFASTA (School of Journalism and Communication), Municipality of General Pueyrredón (Childhood and Youth Directorate), Public Ministry of the Autonomous City of Buenos Aires (Judicial Investigation Body), Trend Ingeniería, UAI (School of Technology), UNDEF (Army's School of Engineering), National Cyber Defence Joined Command, Army's Cyber Defence Directorate, Ministry of the Interior (National Cybersecurity Directorate), UFASTA (School of Education Sciences), Federal Board of Courts and Higher Courts of Justice (Federal Institute for Innovation, Technology, and Justice), Universidad Champagnat (Law School), Supreme Court of Justice in the Province of Mendoza, Public Ministry in the Province of Chaco, UCASAL (School of Engineering).

institutional mandate expressed in the mission of Universidad FASTA. It is the merging of 15 PDTS and 7 R+D projects that were carried out by the FI-UFASTA Research Group in 15 years, and by means of which solutions were given to the issues presented by the requesters, therefore producing 68 scientific publications (6 books). Some of these publications refer, precisely, to the management model of the Laboratory, an aspect that is key to the development of the Ecosystem [21, 22]. That means that, as a result of 10 years of sustained PDTS policy and work, a local innovation micro-ecosystem on Computer Forensics has been consolidated and today it gathers 26 institutions and 138 researchers. All the projects were innovated at a local level and had a high social impact: they developed local technological solutions with local knowledge to provide answers to local issues in the area of computer forensics.

In these 10 years developing the micro-ecosystem, a habitat has been created among the participating institutions where certain efforts, perspectives, and potentialities have been added to generate knowledge and transform it into concrete solutions and innovation. Many internal and external factors have forced the institutions, as individuals and as a group, to dynamically adapt to the changes in their surroundings, prioritizing continuous improvement and innovation as the main goal. For InFo-Lab in particular, and for all the institutions in the micro-ecosystem, the value proposal consists in satisfying the needs of the requesters with the knowledge produced and the technical solutions developed. Each actor in the micro-ecosystem contributes to and creates value that is exploited together. Collaboration, trust, and co-creation of value are key intrinsic aspects in this micro-ecosystem, which has circumscribed its expectations for innovation production to the field of computer forensics and to the Argentine national territory. Shared trust, meaning, vision, and values were progressively developed. Today, it can be asserted that the local innovation micro-ecosystem, promoted by the School of Engineering at Universidad FASTA, has consolidated its local "innovation culture" in the field of Computer Forensics.

6. CONCLUSIONS

In Argentina, in 2013, the National Technological-Scientific System incorporated an instrument to recognize technical development activities that had a social impact, Projects for Social Technological Development (PDTS). Since then, PDTS have become the official unit for recognition of technological development activities with a social impact in Argentina, and its incorporation to the National Technical-Scientific System has a double purpose. On the one hand, it has a technical purpose, and on the other, a political one. The technical purpose is to solve the "issue of recognition" by the National Technical-Scientific System for technological development activities that have a social impact. With regards to the political purpose, PDTS mark the beginning of an effort to specifically promote technological development activities that produce knowledge with a social impact, contributing to the systematic development of innovation and national development.

Given their purpose, the actors they gather, and their interrelationships, PDTS create a space of use and co-production of knowledge that adds value through a unique innovation in terms of originality and local identity. The recurrence of these types of projects in a certain field generates a positive interaction and cooperation spiral that boosts each of the actors' and group capacities. This process leads to the emergence of "local innovation micro-ecosystems," based both on themselves, as well as on their contribution to the country's innovation capacity, and the strengthening of the National System for Innovation.

In the end, PDTS, in time and given their recurrence, can meet the goals of their original policy. The case study of a local innovation micro-ecosystem in the field of Computer Forensics, promoted by Universidad FASTA, is an example that supports expectations in that sense.

The results of this study emphasize the importance of promoting the use of PDTS from national, provincial, and local agencies as a way to boost local institutional capacities, answer society's needs using local capacities, substitute the import of technological developments and products, and mainly contribute to the development of local innovation micro-ecosystems. In this way, PDTS can contribute to the effective and productive consolidation of the National System for Innovation and the realization of its contributions to national development. The multiplication of these local innovation micro-ecosystems, driven and supported by government policies in the long run and promoted by institutions that have a social service interest, would allow the realization of the articulation process that Sabato and Botana proposed in 1968 by means of "sectorial triangles" as instruments to reach the researchers' individual commitment[3] , and ultimately "inserting science and technology in the development fabric itself" for the country [23].

3 "Moving intelligences and wills, the sectorial triangle would act as an integration pole for researchers who, in many ways, are separated from our national realities, giving a social meaning to the existence of the individual and guaranteeing the development of their calling."

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