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From "technology transfer" to local development strategies. Socio-techno-cognitive dynamics in the case of the Yogurito Escolar program (Argentina, 1984-2015)[1]

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Abstract. Innovation and technological change play a role in dynamizing productive development processes aimed at increasing general welfare in the imaginaries of current Latin American public policies. However, there

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is a divide between publicly funded R&D and production, circulation, distribution, and consumption strategies aimed at meeting local social and environmental needs.

Based on the analysis of the socio-techno-cognitive dynamics deployed in the case of the Yogurito Escolar program (Argentina), this paper examines the problems of technology transfer schemes and proposes a range of alternatives for designing public R&D strategies that promote inclusive development processes.

Keywords: Technology transfer; technological innovations; research and development; bio-technology; social development; public investments; Argentina.

Acronyms

APROLECHE	Cuenca de Trancas Dairy Farmers Association (Asociación de Productores Lecheros de la Cuenca de Trancas)
CERELA	Lactobacillus Reference Center (Centro de Referencia para Lactobacilos)
CONICET	National Council for Scientific and Technical Research (Consejo Nacional de Investigaciones Científicas y Técnicas)
DNPYPE	National Directorate for Special Programs and Projects (Dirección Nacional de Programas y Proyectos Especiales)
IESCT-UNQ	Instituto de Estudios sobre la Ciencia y la Tecnología, Universidad Nacional de Quilmes
MINCYT	Ministry of Science, Technology and Productive Innovation
NGO	Non-governmental organization
NIS	National innovation system
OECD	Organization for Economic Co-operation and Development
OTT	Office of Technology Transfer (Oficina de Transferencia de Tecnología)
R+D	Research and development
STA	Sociotechnical analysis
STI	Science, technology, and innovation
SECYT	Secretariat of Science, Technology and Productive Innovation (Secretaría de Ciencia, Tecnología e Innovación Productiva)
SIDTPE	Tucumán Province Secretariat for Technological Research and Development (Secretaría de Inovación y Desarrollo Tecnológico de la Provincia de Tucumán
UBN	Unmet basic needs

1. Introduction

After the publication of "Science: The Endless Frontier. A Report to the President" by Vennevar Bush in July 1945 (Bush, 1945), the linear model of innovation became increasingly established as the organizing logic for science and technology policies around the world and in Latin America in particular.

The Latin American version of the model entails state investment in basic and applied science and, through technology transfer strategies, subsequent conversion by companies into new products, as well as the creation of business opportunities and jobs as a mechanism for stimulating economic development (Thomas, Becerra, & Davyt, 2013a). Thus, the structure adopted by the research and development (R+D) sector in Latin America – and, especially, in Argentina – largely took the form of public R+D units (institutes) that carry out activities "in the laboratory," and then technology transfer by way of licenses, sometimes free of charge, to local companies as a means of survival and growth in conditions of open competition.

Therefore, in the imaginaries of public policy, technological change and innovation plays a role in driving productive development processes in which the ultimate objective is to enhance general well-being. However, analysis of public R+D investment, in Argentina and the region, have pointed to very poor results in terms of technology transfer and adoption (Thomas, Fressoli, & Becerra, 2012; Thomas, Garrido, Fressoli, Juarez, & Becerra, 2014; Arocena & Sutz, 2012). Moreover, close examination of those developments oriented specifically to solving social and environmental problems shows that the vast majority of such projects have been neglected, are underfunded, are not "adopted" by users, and/or give rise to negative and undesirable consequences in terms of pollution and social exclusion by other means (Kreimer & Thomas, 2001; Dias, 2013).

On the other hand, there are alternative strategies that, having broken with the linear model, succeed in "leaving the laboratory" with a production, circulation, distribution, and consumption agenda oriented to solving social problems. These experiences empirically demonstrate possibilities with which to overcome the linearity of institutional strategies for managing science, technology, and innovation (STI), while also providing lessons for steering national and regional STI policymaking towards solving social and environmental problems on a local level.

Specifically, in this study we seek to address the following questions: Why do strategies based on the logic of technology transfer "fail" when it comes to promoting inclusive development processes? Why is there a need to formulate new action strategies so that public R+D institutes

can become key actors in the social and economic development of Latin American countries? How can strategies be developed to this end? With reference to the Yogurito Escolar program – an intensive case of scientific knowledge deployed on a large scale, considered a "success" by various actors – here we seek to explore, in a contingent manner, the way in which scientific-technological capacities are integrated into biotechnology for the solution of a social problem.

Yogurito Escolar is a biotechnology-based dairy product that contains a strain of the *Lactobacillus rhamnosus* probiotic (CRL 1505). Its consumption strengthens the immunological system, helping to prevent respiratory and gastrointestinal conditions (Bortz, 2016). The product was developed by an Argentine public R+D institute, the Lactobacillus Reference Center (Centro de Referencia para Lactobacilos, CERELA-CONICET), and is produced by Cerros Tucumanos, a dairy SME, both located in San Miguel de Tucumán, Tucumán province. The project was initiated between 2003 and 2004 with a view to tackling the problem of child malnutrition among populations with unmet basic needs (UBN) in the province.

Having originated as a social project at CERELA-CONICET, its development represents an intersectoral and interinstitutional effort involving the ministries of Social Development, Education, Health, and Production (Government of Tucumán), the Argentine Ministry of Science, Technology and Productive Innovation (MINCYT), and the Cuenca de Trancas Dairy Farmers Association (Asociación de Productores Lecheros de la Cuenca de Trancas, APROLECHE). Since 2008, Yogurito Escolar is included in the Social Probiotic Program, which in turn is part of the provincial dietary plan. At present, it is distributed – three times a week, as a dietary supplement – by the Tucumán Ministry of Social Development to 200,000 children at public preschools throughout the province.

For a range of actors – scientists, public officials, and decision-makers, in the spheres of both science and technology and social and productive development – the Yogurito program is an emblematic case of innovative social development, and has been showcased by Argentine authorities at international forums as an exemplar of science and technology for social inclusion (Bortz, 2016).

The case provides fertile ground for learning about scientific-technological management, and for designing policies to promote inclusive development in Latin America. In particular, it allows for exploration of how intensive technology can go from solving a specific problem (diseases associated with malnutrition) to be the driving force of a social and pro-

ductive development strategy in which a production circuit is leveraged by strengthening small and medium-sized producers.

In theoretical and methodological terms, we follow the constructivist and relativist approach employed in social studies of technology, based on conceptualizations of sociotechnical analysis (AST; Thomas, 2008, 2012) in order to explore the multidimensionality of processes of construction of knowledge, technology, and policies in the Yogurito case.

This study is structured as follows: the next section presents the theoretical-methodological approach we employ to analyze socio-technocognitive dynamics. Sections three to five reconstruct, from the perspective of the problem-solution relationship, the successive strategies pursued by the actors (with mixed results) during the trajectory of Yogurito Escolar. In so doing, we seek to understand the interactions between subjects and technologies, problems and solutions, the construction of "successes" and "failures," and notions of transfer and collaborative work throughout period under analysis. Finally, our conclusions are aimed at depicting the stylized ways in which the dynamics of inclusive development operate, and how public R+D institutes can affect these dynamics.

2. Theoretical-methodological approach

Our research is based on a theoretical-methodological perspective that triangulates heuristic tools from constructivist studies in the sociology of technology (Pinch & Bijker, 1987; Bijker 1995; Callon 2008) and the economics of technological change (Lundvall & Johnson, 1994; Lundvall, 1988), within a single approach: socio-technical analysis (STA) (Thomas, 2008, 2012).

Evolutionary economics and the economics of technology change (Schumpeter, 1928; Usher, 1955; Freeman, 1987; Nelson, 1995; among others) constitute a way of thinking about socioeconomic and techno-cognitive processes by opening the "black box" of the "technology" dimension (Rosemberg, 1982). For these authors, technological change is understood both as a technical modification (oriented to increasing efficiency and productivity) and as the development and commodification of new products that enable the creation of markets as well as windfalls through the formation of natural monopolies. Thus, firms compete not only on the price front but also do so in dynamic terms, seeking to avoid "lagging behind" in their technological developments (Thomas, Becerra, & Davyt 2013a). This line of argument contends that firms have an incentive to innovate, given that it represents the best strategy with which to prevail in a system of competitive

social relationships. Innovation paves the way for above-average profit rates, which makes accelerated capital accumulation viable.

In short, innovation is a process inherent to a system where competition governs societal rules. But what are the processes and mechanisms that make innovation viable?

Evolutionary economics holds that innovation rests on self-organized processes involving not only technological factors, but also the "context or environment" in which innovation processes unfold. The introduction of the concept of self-organized processes allows for incorporation into the conceptual-analytical corpus of incentives to adopt new technologies, and of capacities for efficient use of innovation (Yoguel, 2000). Innovation and diffusion are components of a single systemic process whereby differentiated rewards are created, giving rise to winners and losers.

Accordingly, the concept of national innovation systems (NISs) is useful for thinking about processes on the systemic level. NISs are built upon two basic structures: the institutional structure and the production structure. A NIS contains "All elements that contribute to the development, introduction, diffusion, and use of innovation, including not only universities, technical institutes and research and development laboratories but also elements and relationships apparently distant from science and technology"[3] (Johnson & Lundvall, 1994, p. 697).

The approach of Lundvall (1992) considers innovation as a collective process carried out by multiple actors, institutions, and social groups involving a range of learning actions associated with routine merchandise (both tangible and intangible) production, circulation, and consumption activities. These learning actions are the inputs for the innovation process. In this vein, Lundvall proposes a new model to explain the innovation-production dynamic, based on the concepts of the learning society and the learning economy (Christensen & Lundvall, 2004).

Lundvall's (1992) conception of the NISs is centered on the contention that innovative activity lies in the system, and is not reducible to its constituent parts: "The important thing about the NIS is not so much the individual characteristic of each component as the relationships and the type and degree of integration between them"[4] (Thomas & Gianella, 2008, p. 44).

Exploring these interactions requires a shift of focus away from firms (as the locus of innovation) towards a set of relationships established by institutions that are overlooked by the traditional literature (Becerra, 2015): R+D

3 Translation by *Apuntes.*
4 Translation by *Apuntes.*

institutions (public and private), governmental organizations, grassroots organizations, NGOs, and cooperatives, among others.

From a socio-technical perspective, it is possible to understand this set of relationships as a system of socio-cognitive interactions in which learning, knowledge, problem-solving, and capacities can be promoted and disseminated. A systemic model of this type combines theoretical contributions from the learning economy and the sociology of technology. Studies about the dynamics and mechanisms of learning (Lundvall & Johnson, 1994; Lundvall, 1992) center on the processes of learning-by-doing (Arrow 1962), learning-by-using (Rosenberg, 1982), and learning-by-interacting (Lundvall, 1988).

Following Thomas and others:

> These three "forms" of learning are related to different types of interaction: a) learning-by-doing, in which learning results from interaction between an actor (and its repository of knowledge, information, and practices) and new technological, institutional, and social practices; as well as codified and tacit knowledge related to an artifact; b) learning-by-using, where learning is a product of interaction between actors and artifacts, through which the actor's capacity to fully use, transform, and rely upon the artifact takes the form of a dynamic process; and finally, c) learning-by-interacting, a concept that seeks to account for the learning processes arising from interactions between the actors (institutions) that comprise a national innovation and production system.[5] (Thomas *et al.*, 2013a, p 11).

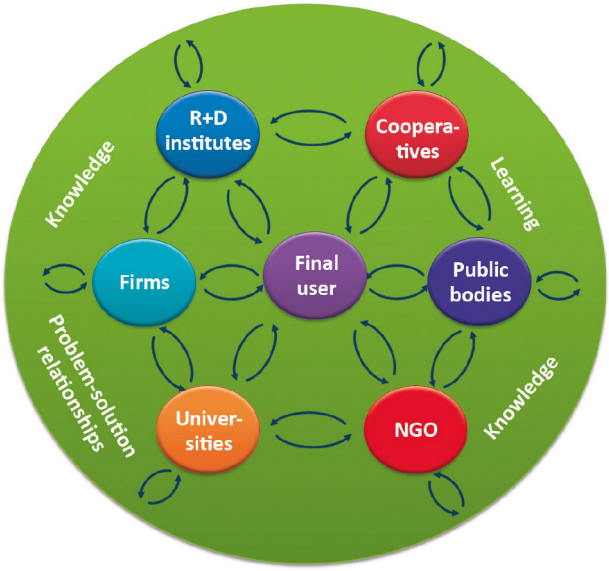
Concurrently, the sociology of constructivist technology concentrates more on interactions than on accumulations (Callon, 2008; Thomas, 2008) and, in particular, formulates explanations in which societies and their technological endowments are co-constructed (Bijker, 1995; Thomas, 2008): artifacts are co-constructed alongside users; users alongside producers; and societies, with the technologies they use (Kline & Pinch, 1996). As part of the same socio-technical process in which technologies are designed, produced, and used, social relations of production, labor, communication, and coexistence are constructed (Thomas *et al.*, 2013a).

The hybridization of both conceptual frameworks gives rise to the "sociocognitive interactive model" (Figure 1). This model seeks to explain, from a systemic perspective, the **interactions** between heterogeneous actors

5 Translation by *Apuntes*.

(universities, firms, cooperatives, R+D, NGOs, public bodies, and end users), **processes** (learning and problem-solution relations) and **practices** (knowledge and capacities).

Figure 1
Interactive socio-cognitive model



Source: Becerra (2015). Translation by *Apuntes.*

The general model assumes free circulation of knowledge and fluidity in the interactions between the various actors that make up the system. Ideally, this will involve the creation of learning experiences and capacities based on broad and open participation in constructing problems and democratizing their solutions. Again ideally, maximizing the interaction processes guarantees the creation of new learning experiences and, by extension, processes of innovation and technological change that are sustainable over time and oriented towards meeting the techno-cognitive needs and requirements of societies.

However, in practice, the systems may contain key nodes or features that define a systemic "style." Thus, a system may revolve around a particular set of institutions, such as profit-maximizing firms. This means that configuring problem-solution relationships, generating knowledge, increasing capacities, and directing learning are oriented almost exclusively to strengthening the role of **one** privileged actor that sets itself up as the node of the system. But are there other options? How are they constructed?

In this study, we use the **term problem-solution relationship** as a key concept to analytically operationalize the socio-cognitive interactive model.

Traditional conceptions in studies of technology, or even conceptualizations based on conventional readings of technology, tend to justify its self-perpetuating evolution by assuming a problem-solution relationship in which "technology evolves through a mechanism for solving technical problems related to previously available technologies" (Thomas, 2008, p. 256).[6] In such cases, problems are generally taken for granted, as if they were not part of sociotechnical processes and as if they were not part of the "nature" of the artifacts, the subjects, the systems, etc.

In practice, "problems" and "problem-solution" relationships can be approached as sociotechnical constructions (Thomas & Gianella, 2008; Fressoli, Thomas, & Aguiar, 2007). Just like the solutions, technological problems (just as social, political, or economic problems) constitute particular, historically situated socio-technical articulations. Now, if the "problems" and "problem-solution" relationships are sociotechnical constructions, then in the co-construction processes between actors and artifacts, the actions of problem-solvers have a relative participation and one that conditions the set of socio-institutional practices, the learning dynamics, the validated knowledge, and the technoproductive capacities constructed.

As such, for STA, the "problem-solving relationship" is analytically enriched when it is understood that, as a result of interpretive flexibility (Pinch & Bijker, 1987),[7] each relevant social group defines the problems differently and, hence, proposes and signifies the various solutions differently. Among other factors, each relevant social group characterizes problems according to: a) its knowledge and know-how; b) the perceived material conditions of the environment and the surroundings; c) its history and prior experiences; d) its socioeconomic situation and socioinstitutional positioning; and e) its ideological configuration.

Finally, it is possible to analytically deploy problem-solution relationships in terms of diachronic and synchronous sequences articulated with problem construction (constructed by different actors) and solution implementation (strategies and technologies). We call these processes **problem-solution**

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6 Translation by *Apuntes*.

7 The notion of **interpretative flexibility** (Pinch & Bijker, 1987) assumes that different actors can assign different meanings to a single artifact based on the type of problems for which the artifact is regarded as a solution: problems which, in turn, can be variously defined by different groups of actors. Analytically, this allows the uniqueness of the artifacts to be deconstructed: insofar as different relevant social groups assign different meanings to the object (expectations, construction of problems, technology evaluation criteria), they "constitute" the artifact differently from another group (Bijker, 1995, p. 75).

dynamics, which enable reconstruction of the processes by which technologies (the solutions) materialize as particular sociotechnical configurations and interactive sociocognitive relationships. Based on this concept, in the following sections we reconstruct the trajectory of Yogurito Escolar, showing how the configuration of different problem-solution dynamics and relationships gradually gave rise to a range of strategies (with mixed results) aimed at steering public R+D to the solution of a social problem.

3. First problem-solution relationship: from therapeutic innovation to differentiated product

In 1984, a medical team from the Niño Jesús de Tucumán Hospital, alarmed by the high rates of infant mortality attributable to summer diarrhea,[8] visited CERELA. This first stage involved the initial construction of the problem, based on the clinical practice of the actors: the inefficiency of the habitual methods of treating childhood diarrhea (withholding food, introducing a liquid diet, supplying antidiarrheals and antibiotics) in cases of severe malnutrition. For the doctors, this problem required a new therapeutic solution. Given this difficulty, the clinical problem was referred to researchers, who were tasked with looking into a possible solution that would provide both nutritional benefits and a cure for children (Lorenzano, 1995).

As a result, the battle against infant mortality shifted from the hospital to the laboratory, and was reformulated as a problem of knowledge in microbiological and immunological inquiry. This in turn meant a transformation of the laboratory's research agenda. The solution proposed by the CERELA team, led by the institute's then-director, a scientist who had received training in lactic bacteria in France, entailed normalizing the gut flora through the introduction of two lactobacilli strains:[9] *L. acidophilus* and *L. casei*. The team found that these strains exercised inhibitory effects on the microorganisms that caused gastrointestinal infections (Perdigón,

8 According to data from the National Statistics and Census Institute (Instituto Nacional de Estadística y Censos, INDEC), in 1983, the annual infant mortality rate in Tucumán was 38.7 per thousand (2012). At that time, summertime diarrhea was the second-highest cause of death among children in the province, accounting for 20% of deaths among that population group (Lorenzano, 1995). That year, these values exceeded the national average by nine percentage points.

9 Lactobacilli are bacteria that yield lactic acid as the main product of their fermentative metabolism. Lactic bacteria is usually present in the human body -- and that of animals -- and some forms have probiotic or beneficial properties for human and animal health. They are acid-tolerant and can therefore survive in mediums where other bacteria would be unable to withstand an increase in organic-acid activity, which makes them suitable for incorporation into certain foods. Moreover, because they remain active in the gut, they exert physiological effects than can have additional therapeutic or preventative benefits.

Macías, Álvarez, Oliver, & Pesce de Ruiz Holgado, 1988), and that these effects were enhanced further when the bacteria were administered orally (Perdigón *et al.*, 1986a). Drawing on these studies, the researchers developed "leche Cerela," a fermented milk prototype with a concentrate containing both lactic bacteria, for doctors at the Hospital del Niño to distribute to inpatients. This yielded better results than therapy based on antibiotics and withholding food, and translated into strengthened immune systems among newborns (Perdigón *et al.*, 1986b, p. 753).

At that time, the development of fermented milk's nutritional and therapeutic properties in Tucuman was considered highly innovative (Perdigón *et al.*, 1986a, 1986b; Oliver, 1994; Lorenzano, 1995). In technological terms, by demonstrating the effects of administering lactobacillus orally, CERELA's findings opened up the possibility of adding lactic bacteria to foods as a probiotic. This implied, in turn, a blurring of the limits – previously highly defined – between the therapeutic, the preventative, and the dietary, by accepting the possibility of "curing" a disease through provision of a food (Lorenzano, 1995).

Once CERELA had completed the R+D stages and the development of the lactic strains, CONICET launched a call for tender through the newly created Office of Technology Transfer (Oficina de Transferencia de Tecnología, OTT). Thus, a specific, risk-sharing technology partnership agreement was entered into by CERELA-CONICET and Sancor Cooperativas Unidas Ltda. for the period 1988-1995 (interview, OTT staff, 2013).

Both the establishment of the OTT (1985) and the agreement between CERELA-CONICET and Sancor occurred as part of a series of public and institutional policies aimed at promoting and regulating links between the scientific-academic system and the production sector, in which legal mechanisms and institutional incentives were also fostered (Dagnino, Thomas, & Davyt, 1996; Hurtado, 2010; Buschini & Di Bello, 2015).[10] These policies were based on the assumptions of the linear science and technology model

10 These policies responded, in turn, to the proliferation in the 1980s of a discourse that was geared towards strengthening links between public academic entities and the private sector, as well as promoting the private firm as a locus of innovation (Dagnino *et al.*, 1996). Although this discourse first emerged in Europe and the United States, the Organization for Economic Cooperation and Development (OECD), the United Nations, and other international bodies played an important role in the diffusion of such institutional models in Latin America (Buschini & Di Bello, 2015). These ideas translated into the formation of new legal and institutional arrangements, through, for example, the promotion of institutions linking universities and enterprises, such as "technology transfer" offices, as well as other institutional mechanisms, including technology parks and business incubators (Dagnino *et al.*, 1996).

(Bush, 1945), and formulated based on a science-pushed conception of the relationship between the academic and production sectors.

Thus, given CERELA's innovative development, for scientists and technology managers alike the technology transfer agreement emerged as the most "natural" and appropriate solution to the problem of devising production strategies based on research outcomes.

However, although the agreement was signed between 1988 and 1989, the product was not immediately made available for sale. This delay was due, on the one hand, to the time required to conduct the pilot on an industrial scale, and on the other, to internal market restrictions and the lack of demand for such products. Finally, the launch of Leche Bio in 1995 and the start of its production and marketing in Argentina, and then abroad, took place amid the restructuring of the dairy industry in the 1990s – marked by changes to the internal market, the arrival of multinationals to Argentina, and the increasing oligopolization of the sector internationally (Dirven, 2001). Innovation in functional foods arose during that period in response to a new and dynamic niche in the dairy industry worldwide, as a strategy for producing differentiated goods to maximize rates of return.

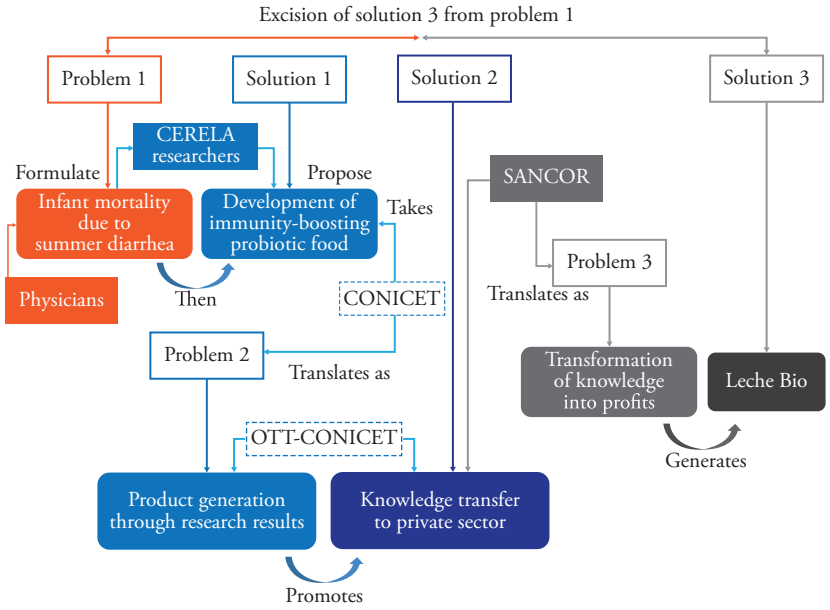
From this perspective, politicians, local STI center managers, and a group of scientists turned Leche Bio into one of the first experiences of "successful" technology transfer to the private sector. On the other hand, other actors involved in its development pointed to the paradox of a technology designed to cure summertime diarrhea being inaccessible to sectors with high levels of UBNs.

During these early stages, the initial problem-solution relationship, oriented towards developing new therapeutic methods for infant mortality, was replaced by the problem of transferring research results to the private sector. The appropriation of this second problem by the enterprise as a way of transforming knowledge into profits and product development as part of a production, circulation, distribution, and consumption strategy based on maximizing benefits meant that the solution developed was poorly suited to the problem originally posed. As part of this shift, the meanings attributed to the artifact, the probiotic food-artifact (and thus the artifact itself) also changed, having gone from being an immunopotentiator for vulnerable populations to a product conceived of for sale.

At this first stage in the trajectory, the stabilization of Leche Bio as a solution subsumed the problem initially proposed by physicians and appropriated by researchers. Moreover, in this initial problem-solution dynamic, the solution proposed, which materialized with the launch of the product, ended up responding to the final (re)formulation of the problem and

breaking with the original problem (Figure 2). And the original problem, in turn, only remained on the agenda of the research group (and, at best, in the project's rhetoric).

Figure 2
First problem-solution relationship



4. Second problem-solution relationship: from the idea-project to transformation of the management model

The profound Argentine crisis of 2001 brought to light the dynamics of social exclusion precipitated by the socioeconomic model of deregulation and economic openness implemented in the country over nearly three decades. In 2001 and 2002, the problematics of unemployment, high rates of poverty and deprivation, and severe deficiencies in terms of health-care and nutrition gained prominence on the public agenda (Demonte, 2011). Particularly in Tucumán, the problems of childhood malnutrition were brought to the fore through media exposure, transforming the social problem into a public problematic that demanded intervention (Gusfield, 1981/2014; Castro, 2002).[11]

11 Various actors point to a television report broadcast in April 2002 about malnutrition and the precarious conditions in which the inhabitants of Tucumán lived as a turning point. The report

CERELA researchers identified this moment as a point of inflection in which the project of developing a functional food to solve the problematic of malnutrition in the province was revived. The decade following the development of Leche Bio had given way to fruitful lines of research on lactic bacteria-based technology and its immunological effects. Along these lines, in the early 2000s, researchers at the immunobiotechnolgy laboratory noted that a strain[12] of *Lactobacillus rhamnosus* (CRL 1505) had a positive impact on the immune response to infectious digestive and respiratory conditions associated with high nutritional deficits, especially when incorporated into the diet through dairy products (Rodríguez, Baigorí, Álvarez, Castro, & Oliver, 2001).

In parallel, on the level of public policy, in 2003 the National Directorate for Special Programs and Projects (Dirección Nacional de Programas y Proyectos Especiales, DNPYPE) was established as part of the Secretariat of Science, Technology and Productive Innovation (Secretaría de Ciencia, Tecnología e Innovación Productiva, SECYT). Some DNPYPE officials, who had participated in the initial experiences of CONICET's OTT in the mid-1980s, saw the science-pushed management model as problematic for the generation of effective linkage processes between scientific capabilities and socioproductive means. To set themselves apart from this approach, the Directorate proposed a management model based on setting up partnership projects through regional multi-actor forums to identify needs, articulate demands, and establish links with actors in the STI system. In 2004, encouraged by the Tucumán Province Secretariat of Technological Research and Development (Secretaría de Inovación y Desarrollo Tecnológico de la Provincia de Tucumán, SIDTPE), the DNPYPE held a multi-actor workshop for north and northeast Argentina in the province, involving scientists, academics, local producers, SME entrepreneurs, NGOs, and political actors from the region.

This exchange between scientists and local and national officials from the fields of science and technology gave rise to an idea-project to develop and produce a probiotic yogurt containing the CRP 1505 strain of *L. rhamnosus*. Thus, almost 20 years from its inception, the goal of promoting the

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featured an interview with a girl who had passed out at school after going more than 24 hours without eating.

12 In microbiology, a strain is a phenotypic variant of a species (in this case, bacterial). It tends to be clonally propagated in response to an interest in preserving certain qualities. These cultures can be used to produce collections that host a large diversity of micro-organisms, in which the taxonomic attribution of each clone is assured. CERELA now has the largest collection of lactic strains in Latin America.

development of children with UBNs was revived. By 2006, the product had reached the stage of laboratory development. For CERELA, its potential implementation required assessment of its impact on the health of children. From the perspective of biomedical research, this meant conducting a clinical trial.

However, doing so meant researchers would face the challenge of assessing technology in the field, beyond the realm of the laboratory. To articulate the implementation, SIDTPE invited the Secretariat of Territorial Articulation and Local Development of the Ministry of Social Development to participate.

The project, which took place between 2004 and 2007, produced the exploratory study "Evaluación de los efectos de la administración de un probiótico láctico en la salud de los niños" (Font de Valdez, 2007), and received a small direct financial award from SECYT (40,000 pesos). The project consisted of the distribution of the yogurt to 298 children between two and five years of age, who attended four community kitchens in poor areas in the periphery of Gran San Miguel in Tucumán. In the trial, which drew on a team of 150 people, 150 children were given the yogurt produced by CERELA for six months, while another 148 received a placebo over the same period, with identical characteristics but no probiotic content.

Assessing the probiotic's impact on child health led to a process of alignment of actors, institutions, know-how, and materials. SIDTPE contacted the Provincial Health System, whose doctors, in turn, involved parents, visited community kitchens to record respiratory, gastrointestinal, and dermatological conditions among children, and collected saliva samples before and after the infants consumed the probiotic. CERELA researchers and SIDTPE officials also held training workshops alongside those who ran the kitchens and the staff assigned to the project, nutritionists and social workers among them.

As well as trialling the product itself (the probiotic yogurt and its placebo), the project also involved studying the results of consumption and associated health checks, as well as assessing the product's reception (liking and acceptance by children and their parents). Moreover, it led to a partnership program with several local actors who had not until then been involved.

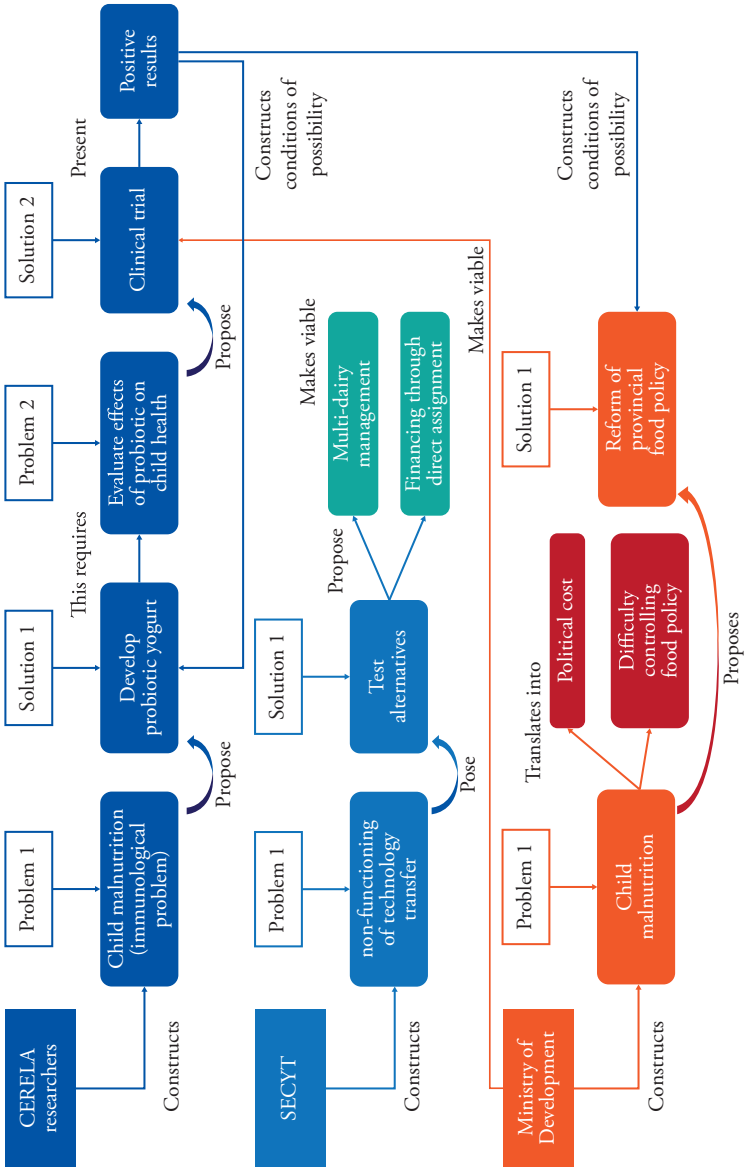
The results pointed to a decrease in the rates of respiratory and gastrointestinal infections and an improvement in children's natural defenses. Specifically, infectious events were recorded in only 34% of the children who received the probiotic, compared with 66% in the control group, while significantly lower rates of cataracts, angina, and summer diarrhea were also detected in the first group. The data obtained by the study (Villena,

Salva, Núñez, Corzo, Tolaba, Faeda, Font, & Álvarez, 2012), published in the press at the time (*El Litoral*, 2008), showed that the children who took the probiotic yogurt were subject to lower rates of respiratory and infectious infections, parasitism, and dermatological conditions, due to the preventative effects associated with an increase in immunoglobulin A antibodies in the mucous.

Based on these results, CERELA, the Ministry of Social Development, and the various other participants constructed the project's functioning, on the one hand, around the scientifically legitimated results observed in the nutritional and health conditions of the children; and on the other, around partnership and problem-solving capacity (Figure 3). Both entities were thus able to establish conditions for the development and implementation of the probiotic yogurt, with a view to attenuating problems associated with child malnutrition. As such, developing the clinical trial entailed an active process of aligning actors and capacities, driven primarily by CERELA, DNPYPE, and SIDTPE, and later also involved the provincial Ministry of Social Development. Thus, the need to conduct the clinical trial on a coordinated basis, as well as the dynamics of responding to the challenges that arose during field implementation, resulted in the progressive expansion of a sociotechnical alliance.[13]

13 A sociotechnical alliance can be defined as a coalition of heterogeneous entities involved in the process of constructing the functioning or non-functioning of a technology. The alliances constituted movements of alignment and coordination (Callon, 2008) of artifacts, ideologies, regulations, knowledge, institutions, social actors, economic resources, and environmental and material conditions to enable or impede processes of sociotechnical change based on the assignment of the meaning of functioning (Maclaine Pont & Thomas, 2012; Thomas, 2012). The actors and technologies that participate in an alliance are strengthened insofar as they succeed in aligning individuals, organizations, objectives, and processes (Latour, 1992). A technology stabilizes insofar as there is convergence in the assignment of meanings to its functioning, and insofar as systemic effects are created in which each element is inscribed in a dense and heterogeneous network of relationships.

Figure 3
Second problem-solution relationship



The dissemination of the favorable results of CERELA's study in the regional press meant a shift in the agency of the object from the laboratory and the community kitchens to the public space. The publicization of the results and the construction of the clinical and social importance of the probiotic yogurt – that is, of Yogurito – demonstrated a technology-intensive solution to a social problematic that had been constructed as pressing.

Given the positive technological results, the Secretariat of Territorial Articulation followed the Ministry of Social Development's lead in expressing interest in supporting the initiative. The proposal to include Yogurito in the Copa de Leche food program was part of a wider reform of the province's nutrition policy, based until then on the purchase and direct disbursement of milk. In response to certain difficulties experienced by the authorities in controlling the program, the Secretariat sought to devise a centralized method based on strengthening school meals in order to improve its own capacity to monitor suppliers, reception, consumption, and the analysis of nutritional results (interview, Secretary of Territorial Planning, 2013). The favorable results of the CERELA pilot, coupled with widespread public approval resulting from press coverage, prompted the Ministry of Social Development to allocate the 3 million pesos provided for by law for the purchase of Tucumán milk (*Ley 7022, Programa Alimentario Copa de Leche,* 2000) to buying Yogurito, for distribution three times per week in San Miguel and Gran San Miguel de Tucumán.

5. Third problem-solution relationship: from food policy to local development strategies

Following the ministerial decision to adopt Yogurito as part of a social food policy, the Secretariat of Territorial Articulation arranged for CERELA and the Trancas dairy belt farmers to produce Yogurito on a provincial scale, and for the provincial ministries of Education, Health, and Productive Development to implement the Social Probiotic Program on a coordinated basis. The inclusion of Yogurito as an artifact in the framework of an intersectoral public policy was aimed at achieving the viability of the probiotic's production and distribution with a view to solving problems of child malnutrition.

The positive outcome of the pilot program marked a shift in the problem-solution relationship: from the laboratory and the construction of the "technical" functioning of the probiotic yogurt in relation to its effects on child health, to the problem of the Ministry of Social Development in making the public policy work. The novel character of the program and the allocation of resources on a provincial level – added to the fact that the reputation of CERELA and CONICET was put on the line – required two

different levels of articulation to be strengthened and stabilized. This meant creating spaces for planning and coordination to avoid potential political costs associated with possible shortcomings in the policy's application, resulting in intersectoral joint management strategies.

> I had to sign off on a policy which the minister would approve, which could not involve anything more expensive, which did not pose a risk to health [...] It had to be something **much** better than what was being done, because it was something new. And because it was something new, it had to be perfect[14] (interview, Secretary of Territorial Articulation, 2013).

Through the collaborative capacities created for implementation of the clinical trial, an organizational technology began to be mapped out in the province to furnish the new project with support, articulation, and impetus through intersectoral efforts. This was also based on an earlier partnership experience carried out by the ministries of Social Development, Education, and Health. For the Secretariat of Territorial Articulation and as far as comprehensive social policy (Cunill-Grau, 2014) was concerned, implementation of the Social Probiotic Program as part of the provincial social food policy required not only introduction of the product and mass-production capacity, but also the generation of an implementation process coordinated at intersectoral level.

To this end, in the first instance the Secretariat, alongside CERELA, placed strong emphasis on training for school teachers and principals. Moreover, the involvement of the Provincial Health System meant physicians at primary care centers in the province could be trained and informed about the start of the program so as to respond to possible secondary effects.

Based on these contacts, largely informal to begin with, an Intersectoral Roundtable was established to manage the project. This process entailed an increase in learning through inter-institutional linkages, as well as stabilization of the connections being developed to overcome implementation problems that had arisen during the previous stage. In turn, this tied in with the provincial Ministry of Social Development's policy need to construct the functioning of Yogurito as an artifact and the program as an organizational technology, which required coordinating the constructions of functioning/non-functioning on the part of the different actors,[15] strengthening each

14 All interviews are translated by *Apuntes*.

15 In the interviews, for instance, two recurrent themes were resistance on the part of teachers to distribute the yogurt in the classrooms, and the need to provide training sessions and workshops to help construct teacher functioning and create processes of empowerment vis-a-vis the project.

of the links in the implementation chain, and aligning elements that could hamper the functioning of the public policy.

The Intersectoral Roundtable, with the representation of the various participating actors, became key to coordinating activities between policy-making bodies (ministries of Social Development, Education, Health, and Productive Development), R+D, (CERELA), and primary production (APROLECHE) and industrial production (Cerros Tucumanos). As the project's primary management entity, the Intersectoral Roundtable was constructed around and **with** Yogurito as an organizational technology that provided support, articulation, and impetus to the project based on intersectoral efforts.

When the Social Probiotic Program was launched in 2008, it supplied Yogurito to 56,000 children in San Miguel and Gran San Miguel de Tucumán. The participation of MINCYT in the National Council for Social Policy Coordination (Consejo Nacional de Coordinación de Políticas Sociales)[16] persuaded the Argentine Ministry of Social Development to support the initiative by earmarking extra financing, in addition to the provincial-level funds provided for by Law 7022 (Programa Alimentario Copa de Leche).[17] This, added to certain gradual changes in the product's packaging to reduce costs, made it possible to scale up production and distribution to 100,000 beneficiaries starting in 2009 (figures 4 and 5).

16 This Council is a dependency of the Argentine Presidency, composed of the ministers of Labor, Education, Health, the Economy, Science and Technology, Justice, Security, and Planning, as well as the Secretary of Childhood, Adolescence and Family. It is chaired by the Minister of Social Development. Its objective is to coordinate the actions, work methodologies, and territorial intervention perspectives with which to approach social policies throughout the national territory.

17 The participation of MINCYT on the National Council for Social Policy Coordination, from 2009 led to various attempts to replicate the project in other provinces. This was at the behest of the Ministry of Social Development, in articulation with the National Comprehensive Approach Plan "Ahí en el lugar" and administered by MINCYT. Their efforts were concentrated on developing the Tucumán project; for an analysis of the evolution of Yogurito in other provinces, see Bortz (2016).

Figure 4
Yogurito in its original plastic container

Source: Bortz (2016).

Figure 5
Dried probiotic powder (Biosec), Yogurito in sachet, and chocolate-flavored probiotic (Chocolet)

Source: Bortz (2016).

The different actors involved in the Probiotic Social Program point to the resulting health improvements, with lower incidences of summer diarrhea and upper respiratory infections. Among the benefits of consuming the yogurt, the Ministry of Education has highlighted the educational gains

enabled by reduced absences and, in the areas where malnutrition is most critical, improved school performance.

But at the same time, the program boosted the recovery of local dairy production. The Trancas watershed, located in north central Tucumán, was historically composed of small and medium-sized family-run dairy farms. The milk was processed by the Trancas Dairy Farmers Cooperative (Cooperativa de Tamberos de Trancas, COOTAM), which in the 1970s and 1980s accounted for 70% of the provincial capital's milk (Garrido, 2005). However, in the 1990s, the policies of economic openness and market deregulation led to land concentration processes, local economic crises, and increases in rural to urban migration. After the collapse of the Farmers Cooperative in 2000, the dairy belt contracted. Producers were atomized, most of them impoverished to subsistence levels, and many abandoned dairy farming. In the period between 2001 and 2008, these farmers made several attempts to unite, in part to meet the provision levels anticipated by the Copa de Leche program. In the face of these problems, steps were taken starting in 2006 to create the Tucumán Province Dairy Roundtable, made up of institutions connected to this production chain.

The beginnings of the public policy in 2008, which required coordinated and constant provision of raw material on a large scale, led to the formation of APROLECHE as an association for entrepreneurial cooperation. APROLECHE's mission was to consolidate the dispersed producers and market their products, seeking to assure them of profitability and stability in order to overcome the structural problems facing dairy production in Tucumán; namely, "[…] the small scale of local industry […]; the entrepreneurial and financial weakness of our sector" (interview, president of APROLECHE, 2013). Thus, while the partnership strategies looked to respond to weaknesses in the sector's production, circulation, distribution, and financing capacities, sustained state demand presented itself as a solution that would set the province's crisis-hit dairy sector on a course to recovery.

The problem-solving dynamics in the sociotechnical trajectory of Yogurito led to a set of learning experiences and new capacities that facilitated the product's adaption, through gradual technological changes, to the territory of Tucumán. These learning experiences came about through extensive negotiation processes centered on heterogeneous knowledge (scientific, logistic, clinical, nutritional, educational and political). The sequences of learning-by-doing (Arrow, 1962) and learning-by-interacting (Lundvall, 1988) involved not only the generation of new knowledge in the interactions, but, for all actors, gave rise to new technocognitive practices: the displacement of habitual practices, immersion in spheres of action from which they were

previously removed, creation of capacities for linkage and joint action alongside different actors, and negotiation between different types of legitimacy and criteria for functioning. In this respect, the institutionalization of joint management mechanisms, such as the Intersectoral and Dairy roundtables, played a key role in the interinstitutional learning trajectory.

In material terms, the diachronic sequence of problem-solution dynamics permitted, in the first instance, installation of refrigerators in school canteens and reorganization of delivery logistics. Moreover, given the problem – detected by the Ministry of Education – of resistance among teachers to distributing the yogurt, the program switched from using liter containers to individual ones. Finally, in response to the Ministry of Social Development's aim of expanding the program's beneficiaries, the SME replaced the plastic bottles with double-wrapped sachets, thus bringing down costs by 70% and enabling an increase in distribution. This learning by doing also made it possible to increase the fluidity of the relationship between CERLA and the dairy SME, facilitating delivery of the probiotic ferment and boosting production flexibility.

In a second instance, the Ministry of Social Development's desire to sustain the program's functioning engendered a product diversification process; to ensure children did not tire of the product, it collaborated with industry to propose and develop Chocolet, a chocolate-flavored probiotic drink whose distribution could be alternated with that of Yogurito. Meanwhile, the Ministry's need to include the rest of the province in the program, added to the problem of refrigerated transportation of the yogurt to the most remote localities, prompted new developments by CERELA – such as Biosec, a dehydrated probiotic that is reconstituted upon dilution in milk or juice. This allowed the program's scale to be increased to 200,000 children, with distribution extended to schools in the province's interior. These developments formed part of a strategy to diversify the functional products developed in Tucumán, and expansion into probiotic cheeses, desserts, candy, and drinks is currently underway.

This process, which gained traction due to the growing demand for raw material with which to fulfill the Social Probiotic Program, promoted and strengthened the formation of APROLECHE, whose identity and reach was gradually constructed through the development of the project and the yogurt as artifact. APROLECHE not only used the administrative and logistical structure of Copa de Leche to provide the milk to make the yogurt, but developed an organizational technology in which they themselves coordinated production, outsourced manufacturing to industry, and delivered the finished product to the Ministry of Social Development. In

this way, as well as through purchase volume, the producers also assured control of production from the raw materials through to the end product, and increased their earnings by delivering a product with value added.[18] This brought about strong growth in the province's dairy sector, which in recent years has been increasing its production volume.

Following on from the Yogurito experience, the efforts of the Intersectoral Roundtable resulted in the formation of a Dairy Technological Pole, run by APROLECHE members and the province's Livestock Directorate with the participation of the Ministry of Social Development and CERELA. Thus, given the problem of the dairy belt's diminished size, boosting value-added dairy production in Tucumán was proposed as a local development strategy. Currently, a set of R+D and production projects are under development, including one to revive traditional flavors for the production of artisanal cheeses, and another for reusing and developing whey.[19] Ñulac, a line of dairy products, was launched in 2014 in order to channel the province's production during the school break, and the surplus over the year, towards a basket of products available at an affordable price for low-income families[20] This Tucumán brand is promoted by APROLECHE, CERELA, the provincial government, and local SMEs (*La Gaceta*, 2014), and is an outcome of the joint and productive capacities enabled by Yogurito and the Social Probiotic Program. The brand aims to consolidate local development dynamics and ensure their permanence, beyond possible fluctuations in the state's purchasing power.

In this instance, it is possible to observe the transformation of some milk producers into a collective actor with clout, capable of formulating problems and aligning with other actors – CERELA and the ministries of Social Development and Productive Development – to find solutions.

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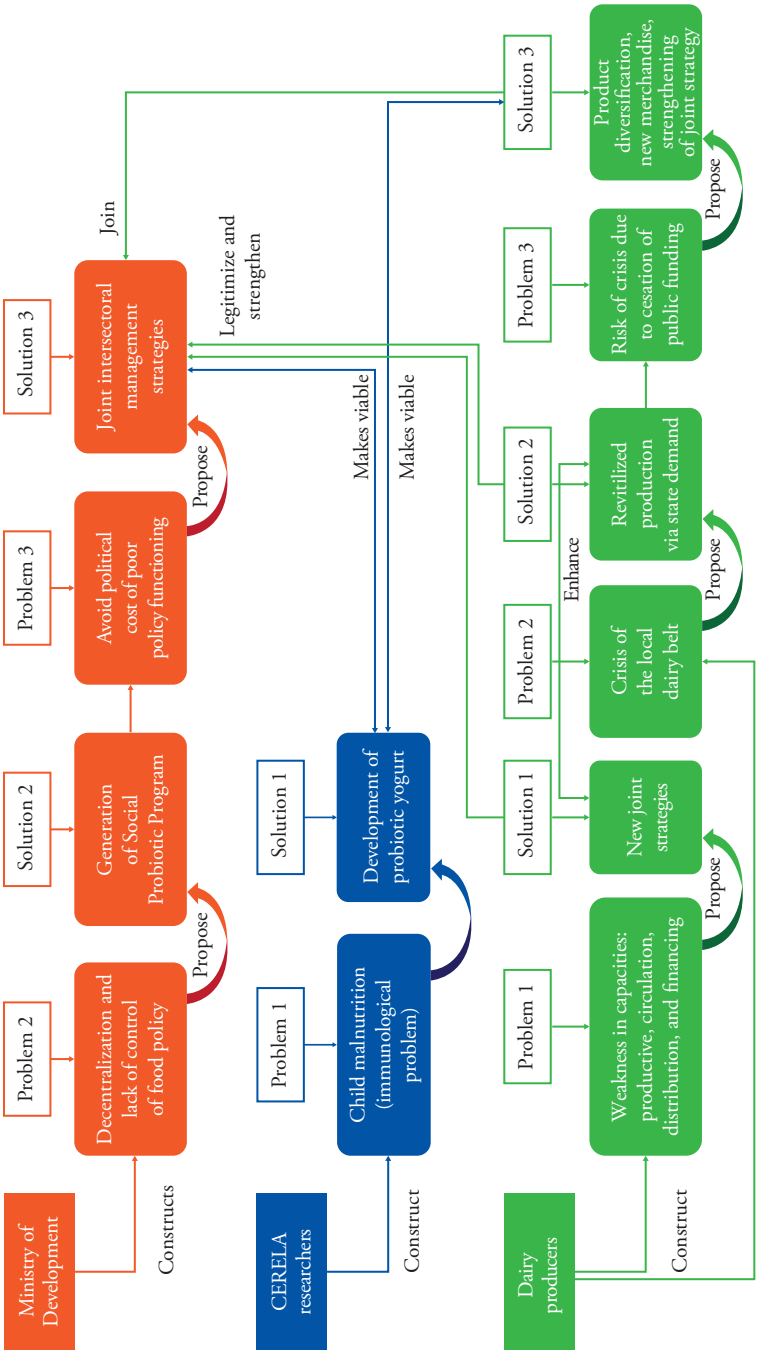
18 The producers add their production to a milk pool that is delivered to Cerros Tucumanos, which manufactures the probiotic yogurt by adding the frozen probiotic ferment from CERELA. The finished product is then sent to the points of production established by the Ministry of Social Development, which in turn pays APROLECHE. The association pays producers based on the number of liters of milk delivered – at a price 20% higher on average than that usually commanded by the market – and Cerros Tucumanos for its manufacturing activity, as well as paying the royalties due to CERELA for the probiotic.

19 Whey is a byproduct of dairy production with a high level of protein, but its disposal results in high levels of pollution. The drying of whey has become important in recent years, as it allows this byproduct to be transformed into high-value proteins used in the dairy industry for their functional and nutritional qualities (Gutman & Lavarello, 2014).

20 The development of a line of Tucumán dairy products was also constructed as an alternative to resistance on the part of some producers to participate in APROLECHE, and to supply the Social Probiotic Program, given the absence of milk deliveries during the summer months. In addition, this was complemented by various administrative strategies to reduce state delays in paying suppliers.

The new joint management strategies pursued by the producers, as well as the product diversification in the Trancas dairy belt, on the one hand, respond to the producers’ need to strengthen the sustainability of local development dynamics based on the Probiotic Social Program; and on the other, contribute to the dairy belt’s growth by consolidating it, despite the ever-present risk of fluctuations in the public funding allocated to social food policy (Figure 6).

Figure 6
Third problem-solution relationship



6. Conclusions

In this study we analyzed the different ways in which the relationships between problems and solutions were constructed for the creation of a functional food that started out as a biotechnical proposal for improving the health of children in conditions of social vulnerability, and ended up as a complex socio-productive program. On the basis of this, it is possible to arrive at conclusions on (at least) two complementary levels: one empirical and the other, theoretical.

Empirical conclusions

The first problem-solution relationship operates based on a notion of technology transfer oriented to solving the problem of malnutrition. As we analyzed in depth in Section 3, this way of thinking about the design and development of technologies culminated in the non-functioning of the program of action in the terms in which it was first envisioned. In stylized terms, it is possible to assert the existence of a dissociation between the problem-solution relationship, the capacities generated, the key actors selected for program implementation, the learning experiences imparted, and the knowledge developed. This is because, insofar as the sequence of problem-solution relationships is consolidated, it is the firm that ends up translating and concentrating the assignments of meaning and the practices of the remaining actors in terms of its own problem-driven agenda.

In the second problem-solution relationship, there is a shift in the idea of transfer (a public R+D agent that licenses its developments to a private producer) to an internationalization strategy involving a good's entire development sequence (R+D → prototype development → testing → product development → distribution). It should be noted that this problem-solution dynamic is not the result of any deliberate acts on the part of CERELA, but the contingent construction of relationships between actors and technologies borne of problem-solving actions. Although the idea of transfer shifts, the knowledge and product development process remains concentrated on a single actor, no longer a firm: the R+D laboratory. In this case, despite the centrality of the R+D institute, the concentration dynamics differ from the previous case, as can be observed in Table 1.

Table 1
Differences between the first and the second problem-solution relationship

Dimensions	First problem-solution relationship	Second problem-solution relationship
Who benefits?	The private firm, the public R+D laboratory, the national council of science and technology.	The public R+D, the user-consumers, and the local dairy SME.
Who governs the link?	The private firm.	The public R+D laboratory.
How does the research agenda relate to the problem to be solved?	Dissociation resulting from the commodification of technological development.	Alignment between the research agenda, the sociopolitical objective of the R+D, and the original problem to be solved.
How does the research agenda relate to the implementation of solutions?	It is governed by maximization of profit rates.	It proposes partnerships and partnership capacities.
What subsequent stages does it make viable?	Stabilization and continuity of the commercial solution and private appropriation of the revenue from publicly generated knowledge.	Transition to a problem-solution relationship dynamic associated with the creation of inclusive technoproductive processes.

The third problem-solution relationship goes beyond the limits of R+D agendas to incorporate the problems of public bodies and productive actors present in the territory, by devising a local development strategy. This problem-solution dynamic encapsulates the largest number of particular heterogeneous problems in a single definition of strategic action. The links established between the actors are more fluid and horizontal than in the previous cases and, as such, the learning processes, creation of capacities, and construction of knowledge acquire a status of greater potential. In more concrete terms: the probiotic yogurt is developed; the public policy is constructed; the producer association is created and constructed as a collective actor; primary and secondary production is activated; the children become effective beneficiaries of the public policy: school absenteeism decreases; rates of diarrhea and respiratory and gastrointestinal infections decrease among children from low-income families; and the groundwork is laid for subsequent partnership strategies.

Unlike in the first instance, in which CERELA loses control of the process and product development comes to be governed by the firm; in this third problem-solution dynamic CERELA does not lose sight of the

original problem: responding to diseases related to food shortages. But at this point it does so through a different strategy: CERELA retains its focus on the original problem because it binds it up in more fluent problem-solution relationships (De Laet & Mol, 2000) in contrast to a highly rigid relationship, such as that constructed in the first instance. Thus, in the first strategy, CERELA's problem is subsumed and diluted in problem-solution relationships configured both by the transfer office and the private firm, and so the final product proves inadequate in relation to the initial social problem. In the third strategy, the initial problem posed by the R+D institute incorporated – and was incorporated by – the problems of public bodies and actors in the territory. The confluence and distillation of heterogeneous sectoral problems into an action program (not without resistance and negotiation along the way), and a distributed mode of governance, gives rise to a non-linear form of management and action to devise, at the same time, a social food policy and a local development strategy.

Theoretical conclusions

The second level of conclusions are theoretical and enable us to respond second-level analytical questions.

· What types of co-constructions are generated in the three stages in relation to the local development strategy?

In the first dynamic (Figure 7), the profit-maximizing firm selects and promotes norms connected to reinforcing the appropriation of benefits and, thus, the appropriation of knowledge. In the second case (Figure 8), the R+D institute centers the system on recovering its central objective and reestablishing the agenda oriented to solving local problems.

Figure 7
Interactive socio-cognitive model centered on the firm

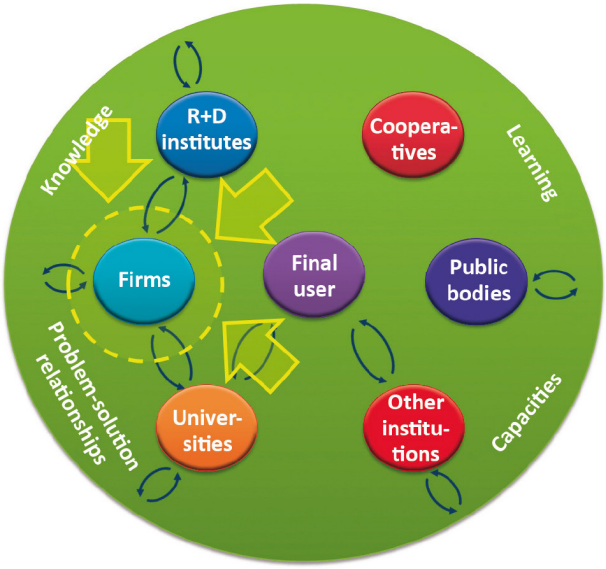
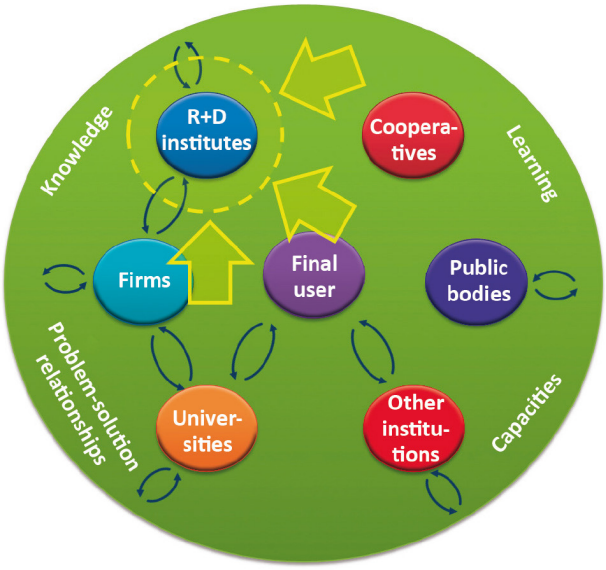
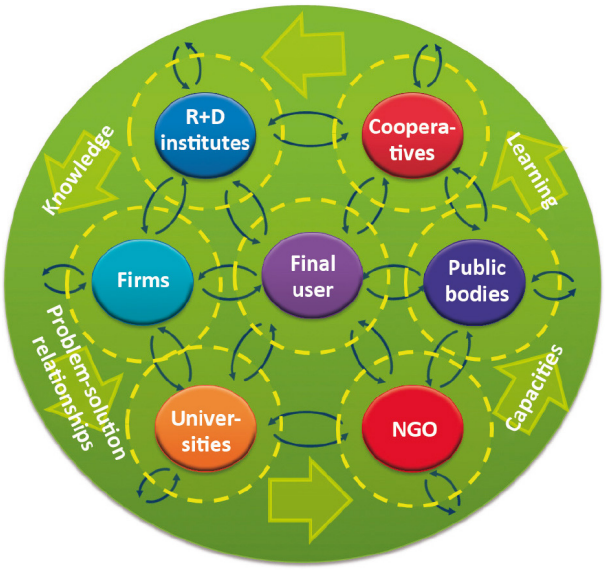


Figure 8
Interactive socio-cognitive model centered on the R+D laboratory



While in the monopolistic appropriation model the benefits of knowledge flow, at least for a time, in a single direction from society to the firm, in the collaborative model the innovative process operates in a centrifugal manner, since it is the collective that learns and develops the goods to be produced and circulated. In this way, at the other end of the spectrum to the firm-centered interactive model (Figure 7), in which profit maximization is based on the centralization and monopolization of knowledge or resources, the collaborative network (Figure 9) promotes the socialization of benefits. These collaborative dynamics orient innovation towards the circulation of collective learning, distributed generation of capacities, and validation of heterogeneous knowledge. The construction of collaborative links substitute monopoly, competition and private profit as the engine of innovation, and diffusion increases the potential sustainability of the experiences, thus multiplying the effects in terms of development and inclusion.

Figure 9
Interactive socio-cognitive model based on collaborative networks



· What systemic styles are configured? How do these styles operate in the system dynamics?

A system can revolve around a particular set of institutions, such as profit-maximizing firms, or an R+D institute, or may be decentralized as a series of heterogeneous relationships. What does this involve? For example, if we take the cases shown in figures 7 and 8, the configuration of problem-solution relationships, knowledge generation, capacity increases, and

the direction of learning are oriented almost exclusively at strengthening the role of the nodal actors (the firm or the R+D institute) as the legitimate innovating agent.

Still more important is understanding why such styles in which the system is centered on a private concentrating node restricts (rather than strengthening) the possibilities for learning and, by extension, formation of new and innovative dynamics. This is because the knowledge management dynamics are translated in terms of the materialities specific to each type of institution, which can range from the acquisition of monetary gains to the pursuit of recognition in the scientific-technological field. There is a need to clarify that this is due not to the status of the individual unit, but, as we have noted, to the type of systemic environment in which the profit-maximizing firm is immersed. The enterprise exists in a systemic environment in which knowledge and learning are ways of obtaining dynamic competitive advantages.

Breaking with the dynamics of pursuing "learning rents" therefore requires the construction of more decentralized and multi-institutional styles, such as those shown in Figure 9, that enable the construction of more fluid interactions.

· What types of models of accumulation have been developed?

The style shown in Figure 7 represents models of accumulation based on increasing the profit rate, with spillover effects on the living conditions of the lower classes. The concentration of income is an inescapable result of the appropriation, exploitation, and control processes involved in the commercial and productive cycles. In this model, competition between firms gives the system a self-reinforcement mechanism: even when firms seek to abandon the capital optimization dynamic, the latent risk of being displaced by others blocks possible alternatives.

The dynamics represented by Figure 9 attest to the possibility of models of accumulation based on the notion of equal development and fairness. This figure represents the axiotic basis of the interactive socio-cognitive model, founded on collaborative networks of interinstitutional coordination and cooperation. Public R+D strategies can be oriented towards models of accumulation based mainly on inclusive development by casting aside the traditional strategies, which reproduce a systemic style of appropriation particular to sociocognitive production, and focusing more on the construction of broader and more heterogeneous networks of actors, technologies, problems, and solutions.

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