Science, Technology and Innovation for Social Inclusion: experiences, struggles and policy opportunities

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Mariela Bianco[1]
CSIC Academic Unit
Universidad de la República, Uruguay
www.csic.edu.uy

1. Introduction

The purpose of this paper is to present some ideas relating science, technology and innovation and their role in providing solutions for some of the problems generally circumscribed to the social inclusion of disadvantaged social groups in developing countries. It does not intend to be a thorough review of the state of the art on the topic or the problems related to it; rather it is a personal selection of aspects based on the general context of poverty and inequality of Latin America, the territory to which I belong, and of actual situations of knowledge creatively put into practice to illustrate challenges and opportunities for policy development.

The ideas in this document are drawn from specialized literature on the general topic of knowledge in developing countries, personal experience working at the research council in a public university setting throughout two decades, and collective concerns and ideas shared among members of an interdisciplinary academic group focused on issues of science, technology, innovation and society[2].

2. A glimpse at the Latin American context

In 2010, the poverty rate in Latin America was 31.4%, including 12.3% people living in extreme poverty or indigence. These rates have been reduced since 1990; however in absolute terms, they still translate into overwhelming numbers of people living in unacceptable conditions: 177 million poor people, of which 70 million are

[1] Contact information: J. Jackson 1303, Montevideo 11.200, Uruguay. Email: sur@csic.edu.uy

[2] The Academic Unit of the University Research Council (CSIC) in the University of the Republic, Uruguay.

indigent (ECLAC, 2011). Moreover, income distribution in Latin American countries is among the most unequal in the world. Persistent inequality reproduces everyday situations of social exclusion for ample sectors of the population. According to Sen's (2000) notion of social exclusion, people in this situation are deprived of the capabilities to develop a full life and to share the opportunities that others in the same society enjoy. Relational deprivations may have constitutive or instrumental importance depending on historically situated contexts. At present time, these deprivations in Latin America depict homeless, landless, undernourished, sick, unemployed, mentally ill, illiterate people.

Inequalities between individuals, social groups, countries or geographical regions are reinforced by unequal conditions of generation, access and use of new technologies where knowledge has acquired the role of a power instrument (Arocena and Sutz, 2003, 2009; Soares and Cassiolato, 2008). In Latin America, economic growth and enhanced competitiveness fueled by science, technology and innovation (STI) in several economic sectors coexist side by side with poverty, malnutrition, inadequate health and housing conditions in both urban and rural areas. In fact, innovation itself is sometimes a cause of greater inequalities in Latin America increasing existing gaps within particular economic and social sectors or between formal and informal economies. By this situation, substantial portions of the Latin American population is excluded from the benefits of innovation while, at the same time, a minor portion lives by the same technological standards than populations in developed countries.

Most Latin American countries have an endowment of natural resources that constitutes a comparative advantage for agriculture. To fulfill that potential it is necessary to produce, process and trade high quality products at competitive costs for which technology has a fundamental importance. For decades, public STI efforts have been focused on the improvement of subsistence and commercial crops. However, contradictions and inequalities regarding knowledge use and innovations' socioeconomic impacts proliferate in agriculture. Some examples include the diffusion of BT cotton in northern Argentina (Arza et al., 2011), the contradictions between scientific and native potatoes in the Peruvian Andes (Salas, 1994), the impact of tractorization in the replacement of peasant farms by commercial agriculture on the outside area of Mexico City (Ocampo and Palacios, 2002) among so many others. Moreover, according to the Food and Agriculture Organization the 10 major subsistence crops in Latin America are grown in less than 10% of the total cultivated area (Pomareda and Hartwich, 2006).

Nevertheless, STI potential for improving social and economic dimensions is not to be underestimated. Academic research and innovation may be powerful instruments for the reduction of particular inequalities, especially those related to poor living and social exclusion. The tentative argument of this paper is that STI can successfully be oriented by policies, to reduce particular inequalities in developing contexts. That is, STI policies are necessary to meet the needs of the most vulnerable groups in a population understood as those who do not have by themselves the capabilities and opportunities to escape poor living.

3. Innovation traits in developing contexts

Innovation in this paper refers to problem solving. The notion involves ideas, procedures, objects perceived as new by individuals, groups, economic sectors, regions or countries applied to an existing problem. Typically, innovations result from a cumulative process for the generation and use of new knowledge or new combinations of existing knowledge applied to the solution of a practical problem. Innovations involve continuous interactions among different actors who share learning spaces in which creativity and problem solving abilities maximize each other (Lundvall, 1992; Sutz, 1997; Arocena and Sutz, 2003).

In the sense described, innovation does not rely only on R&D; in fact, in many cases it is increasingly based on the incorporation of already existing fragmented knowledge, the articulation of tacit and expert knowledge where articulation capacities and appropriation mechanisms are fundamental. The successful combination of different sources of knowledge for problem solving is on the basis of innovative attitudes and the search for solutions in adverse conditions may be highlighted as a trait of developing countries.

Perhaps, the most salient characteristic of innovation in developing contexts refers to the ability to innovate under scarcity conditions (Srinivas and Sutz, 2008). Scarcity conditions refer to lack of sufficient or adequate infrastructure, equipment, institutional support, trained people, and/or money to develop new and different ways to solve problems. Under these conditions, solving problems usually "implies a challenge that must be faced with high doses of creativity."[3] Therefore, major problems with no or inadequate solution for developing countries may trigger innovation processes. Scarcity induced innovations, can result from the following situations:

- the need to solve problems that have already been solved somewhere else in the world but for which the existing solution is inappropriate or too expensive to be adopted in developing contexts;
- problems that still do not have a solution either in developing or developed countries;
- problems of replacement, that is how to build a known device replacing some of its components, or the machines used in its manufacturing, by other components or instruments, obtaining similar performance.

[3] According to Srinivas and Sutz (2008) there is a substantial difference between scarce resources in developed countries and scarcity in developing contexts. In the latter scarcity means restricted access to possibilities that are abundant in highly industrialized countries as well as demands that have been, to a great extent, already solved in developed contexts.

As suggested in the previous section, innovation in Latin America is not necessarily oriented to the satisfaction of needs and demands from social groups facing poor living conditions. While, several problems of undernourishment, poor housing or access to health services could benefit from STI contributions, local or national research and development efforts in the Latin American region are not clearly devoted to them. In the absence of local, national demands, STI endeavors are mostly driven by international agendas and academic incentives not necessarily connect to production or social needs in developing contexts. Thus, research is mostly focused on the solution of science puzzles or on the generation of technology rather than on problem solution with socioeconomic impact. In fact, underdevelopment today is characterized by a mutual interaction between high levels of inequality and limited knowledge endogenously generated (Arocena and Sutz, 2009). In a particular way, scarcity conditions are also present in the ideas and motivations that drive STI in developing countries. That is not to say that scientists and technologists are vocational mere observers on the side, but in order to target STI to specific impacts on improving living conditions, specific policies are needed to conceive social inclusion as a STI goal. With appropriate incentives, the ability to innovate under scarcity conditions might be essential to creatively approaching some of the problems of social exclusion that can be "solved" by STI.

4. Social inclusion as STI goal: ideas and examples

Social inclusion problems are conceived as those that severely affect the quality of life of particular groups in a population, at material and symbolic levels, representing disadvantages to individuals that come to be excluded from the opportunities available to others (Alzugaray et al, 2011). According to this idea, social inclusion problems may involve unmet needs associated with employment, education and training, environmental pollution, habitat and housing, physical and mental health, violence, poverty, among others, for which knowledge from combined disciplines can contribute creative solutions (Bianco et al., 2010). Solutions may be new products, processes or forms of organization that could be implemented by a diverse set of actors involving public institutions, NGOs, firms in the private sector, international cooperation, and community organizations, among others.

According to Gras (2012) inclusive innovation is a type of innovation leading to a solution that contributes to reducing social exclusion and deprivation of capacities (constitutive and instrumental) suffered by the least favored sectors of a population. Inclusive innovation results from a complex social process involving the interaction of heterogeneous agents (those who have or set forth social needs and those with scientific-technological and productive capacities that can contribute feasible solutions). According to this author, the main differences with other types of innovation are that social demands or needs (explicit or implicit) originate the search for creative solutions and that social objectives are at least as important as economic ones.

Now, how can the connection between social inclusion problems and the provision of viable solutions derived from the creative combination of different sources of knowledge be fostered? It has been for the most part evident that this articulation does not just happen by itself. Special incentives are needed for the promotion of more comprehensive and connected research and innovation agendas that could foster feasible solutions for social inequality derived problems. Despite the attractive character of the idea of inclusive research and innovation, the truth is that there are plenty of complexities involved in the process and STI agendas do not easily incorporate social inclusion issues.

Based on the experience of the public university in Uruguay[4], some of the reasons listed by Randall and Sutz (2009) help us to understand why social inclusion topics are not easily integrated into STI agendas. I will comment on four of them. For almost a decade, a competitive program has been promoting research and innovation projects oriented to social inclusion in all knowledge disciplines. The number and quality of proposals presented to the three calls of this program have been increasing since the first one in 2003. However, it is still perceived by large sectors of the university community that poverty and exclusion problems belong to the sphere of social policies and have little, if any, in common with STI. This is a widespread idea derived from the simplified notion that poverty and exclusion are a consequence of income shortness and therefore can be alleviated with adequate employment policies or cash transfer programs.

In addition, most vulnerable sectors in a population and the social organizations working in the development of strategies to overcome social exclusion do not conceive STI as a viable path capable of providing solutions to the most pressing social problems. Together with the limitations of researchers mentioned in the previous paragraph, this operates as a double barrier which establishes mutual invisibilities between, on one side, researchers who do not identify social problems as possible objects of study and, on the other, social sectors not perceiving those involved in STI as possible partners in the implementation of solutions to their problems (Bianco et al, 2010).

Furthermore, frustration emerges associated with research solutions found but then not implemented in practice due to lack of coordination among different actors having a part in the decision of problem resolution. It is evident that in addition to new knowledge, the articulated will of different actors is an essential ingredient for the actual implementation of a solution (Alzugaray et al, 2011). This circumstance operates as a strong disincentive for socially sensitive researchers trained in the agricultural, natural sciences or engineering to get involved in complex research topics related to social issues.

Lastly, for an increasing number of researchers, conducting projects on social inclusion topics requires an additional effort fighting against traditional rewarding

[4] The Universidad de la República is Uruguay's state university and the only institution in the country conduction research in all fields of knowledge. Its mission is threefold. It is committed to higher level education in all cultural and scientific fields, to the generation of new knowledge based on scientific and technological research, and to the diffusion of knowledge and services to the different sectors of society through extension.

academic mechanisms which run on the opposite direction. Most scientists are driven by a desire for academic recognition and reputation that can improve their careers at highly recognized institutions. Evaluation and promotion of researchers at universities and research and development centers focus mainly on publications and patents which are not exactly in line with the type of recognition that inclusive STI raise.

Despite all difficulties highlighted, there are many interesting examples that can motivate useful thoughts for the discussion of policy design in developing contexts. I shall describe below three different examples from Uruguay in order to illustrate with experiences purposefully oriented to provide solutions to particular unmet social needs.

Case 1: *Human Milk Pasteurizer*[5]

Human milk banks supply donors' mother milk to babies that, for varied reasons, cannot be breastfed. Human milk provides nutrient and immunological components that cannot be replicated by formula milk. Maternal milk is especially important for premature and ill babies. The World Health Organization and UNICEF encourage donor mothers' milk as the first alternative where own mother's milk is not available. Screening and pasteurizing donated human milk ensures the absence of infection and disease. Pasteurization is the procedure that eliminates bacteria while retaining most milk's beneficial components. Donated milk needs to be pasteurized at 62.5 C for 30 minutes in a device called pasteurizer.

The first human milk bank was established in Uruguay in 2004 in a public hospital located at a four hour distance from the capital city. The bank was created in an attempt to reduce newborn mortality rate. A pasteurizer was required for the bank to operate. A local technician from a small dairy industry was in charge of the creation of an innovative pasteurizer developed from the scratch in response to a concrete demand from the hospital. The novelty of the local pasteurizer is mainly the automatic mechanism that substitutes the most popular method of a shaking water bath and human controlled temperature. The advantages of the new pasteurizer are that can be assembled in less than a month with components found at a regular spare parts store at a third of the cost of a commercial equipment. The components include an electric heater from a domestic frying machine, the windshield wiper motor of a car, a washing machine water pump for cold water and another pump from a dishwasher for hot water. The most sophisticated part is a programmable controller (PLC) with 30 functions for the automatic procedures that was implemented by a programmer. The pasteurizer requires minimum training and maintenance to be successfully operated.

[5] Source: Research on Innovation Systems and Social Inclusion, RISSI Project (Brazil, China, India, South Africa and Uruguay). http://www.redesist.ie.ufrj.br/rissi/

Case 2: *Improved Strawberries for Small Farmers*[6]

Strawberries are traditionally grown in the Northern region of Uruguay by local families sharing a horticultural tradition for more than a century. In the 1990s, strawberry plants were increasingly infected by anthracnose, an important plant disease caused by several fungi. The disease spread quickly destroying the fruits with crop losses of 30 to 50% of production. In this scenario, growing strawberries was too risky for family farms entirely depending on farm income. Strawberries would have been disappeared from that area without the articulated intervention of agricultural researchers at the National Agricultural Research Institute, and technicians that propagated the technology to organized farmers.

The technological solution implemented included: i) strawberry seedlings grown in greenhouses instead of on the open ground and transplanted in pots to the field to reduce disease spreading. ii) development of five new strawberry varieties of improved sanitary quality each of them validated during two years on farmers' fields before commercial release. iii) multiplication and commercialization of seedlings of the new varieties by farmers trained at the agricultural research center in collaboration with farmers organizations.

Strawberry production increased significantly in the 2000s in terms of the cultivated area, yields and number of producers. By the end of the decade, cultivated area was a third larger, average yields have doubled and the number of producers augmented by 60%. However, most importantly the survival of farmers in the area was possible by reducing the uncertainty of a crop that requires intensive care. In this sense, technology positively contributed to the permanence of farmers in the area with improved living conditions and maintaining local horticultural traditions.

Case 3: A*rtificial (synthetic) Skin for Severe Burns*[7]

In Uruguay there is a high incidence of burns in disadvantaged populations due to heating systems used and precarious housing materials (wood, cardboard, and plastic). The cost of damaged skin replacement by skin synthetically produced is extremely high. Commercially available skin is imported and cannot be afforded by the population that suffers most skin traumas caused by burning. The State cannot provide enough skin for all the burned people and individuals can not afford their own costs. This seriously compromises the survival probabilities and the later quality of life of those injured which include a majority of children and elderly.

In 2010, synthetic skin was produced in a university laboratory based on bovine collagen which is discarded by the local meat industry. A low cost prototype was developed based on the availability of local inputs, research skills and laboratory

[6] Based on interviews with researchers and Vicente, et al. (2007).

[7] Based on Alzugaray et. al (2011) and Gras (2012).

facilities. The research idea emerged at a university team recognizing the opportunity to provide a technical solution to a known social problem. However, the scaled production of artificial skin requires the involvement of firms that exist locally but are not willing to take the risk of product development without the certainty of economic benefit. Since those in need for the product are not able to buy it, given their low income condition, the intervention of the Sate is essential for the solution to come full circle. The incentive of by public procurement is required to move the research solution to the production sector and therefore make it available to the public health system. However, synthetic skin is not a priority for health authorities in charge of public procurement decisions. The idea originated in academia but fails to take life outside of it; therefore there is still no effective solution and the need persists unmet.

The three cases described, depict different situations and opportunities. **Case 1** is an example of innovation of the third type in the classification of Srinivas and Sutz (2008). A concrete demand triggers the search for a practical solution that requires building a known device by replacing their components and, in this case, improving its performance. The final artifact is not developed by academic research but by locally available technical knowledge. The solution is successfully implemented to satisfy the local need, but so far, not replicated to other similar contexts. **Case 2** is an example of a technological result developed at a research center on the basis of expert and local farmers' knowledge where a social network was available facilitate for appropriation of the solution. This example and **Case 3** resemble the first situation of scarcity induced innovations in which existent knowledge needs to be adapted to the particular context of application. **Case 3** is an example of a promising innovation developed at a university setting that could not move beyond the prototype stage. Despite the fact that the product developed adequately serves the need for which it was created, it cannot be socially appropriated and put into use because the articulation of actors having a part in the implementation fails.

5. A role for policies

Obviously, for STI to flourish in developing contexts, setting the right policies is not enough. However, it is reasonable to believe that inclusive STI can be facilitated by policy improvement. For decades in Latin America, there was no political commitment to endogenously foster STI. Typically, policies have concentrated on the supply side and were informed by an absurd separation between the economic and social dimensions of development. A clear understanding of the social and economic consequences of STI on different social groups has been, to a large extent, missing. In recent years, this situation has started to change in several countries and more efforts are committed to the understanding of the central role of knowledge on development and the need for policies to foster better living conditions and not only economic growth. Therefore, a friendlier environment is emerging for accelerating more socially oriented courses of action.

A purposeful search for a more equitable distribution of knowledge benefits is required if STI are to be conceived as instruments to have a positive impact on social

equity and sustainable development, beyond institutional and political discourses. In this sense, STI steering is necessary on the basis of interdisciplinary approaches and integration of different types of knowledge such as local, technical and scientific. Social inclusion and improved living conditions cannot be seen as a natural consequence derived from improved performances associated with productive and/or economic results. Generating significant impacts on the quality of life of deprived populations requires taking into account their needs as early as the stage of research and technology design. Science and technology should anticipate desired impacts at social, economic and environmental levels, identify the agents that need to get involved for these impacts to take live, establish the goals to be attained and their appropriate indicators for assessment.

The importance of interactions among government, productive sector, and academia for development was highlighted more than four decades ago in Latin America by Sábato and Botana (1968). Nowadays, the context of inequality in the region also calls for the articulation of those sectors of the population that demand or need social inclusive innovations. However, the passage of time has shown that these articulations do not occur in a systemic way without specific policies for their promotion. STI policies for social inclusion, using diverse mechanisms such as focused competitive funds, tax exemptions, public procurement, scientific and professional internships in social organizations, and so many others, can focus on influencing topic selection, research styles, and private sector involvement. Political will translated into adequate signals are essential for the promotion of a STI agenda oriented to social inclusion. As Gras (2012) states, the more incentives and coordination among public policies, the more needs can be met and agents willing to participate in the creation of inclusive innovations.

Finally, STI needs to be brought into much more communication with users. However, researchers by themselves cannot play all roles being at the same time in the field, the community, the classroom, and the lab. Intermediary organizations and STI agencies are required to actively take part in identifying demands and unmet needs and putting them in touch with knowledge capacities; that is creating linkages among those who know something with those who need something. As pointed out more than ten years ago by Gamble (1997), for this endeavor, social scientists in general, not only economists, need to be an integral part of the team. Together with "harder scientists," and users they can bring a sharper focus to STI in order to contribute to improved lives.

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