# Integrating Innovation Policies with Social Policies: A Strategy to Embed Science and Technology into Development Processes

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**Abstract**
Fostering innovation and increasing inequalities often come together, particularly in underdeveloped countries. Development strategies need to promote ways to diminish inequalities that are positively correlated with increases in collective capabilities to learn and innovate. This paper explores the conjecture that progress can be made when innovation policies are directly connected with attention to the most pressing social needs. Empirical evidence stemming mainly from bioinnovation is presented to support the conjecture. Some recommendations for the integration of innovation policies with social policies are presented.

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## Presentation

Accumulation of knowledge and innovation have generally not been strongly backed by economic or industrial policies in developing countries in general and in Latin America in particular. This is in sharp contrast to countries that experienced rapid social and economic improvement in the second half of the 20th century (e.g., South Korea and Finland). Developmental divergences between countries that showed impressive similarities 100 years ago (e.g., Scandinavian countries and those of the Latin American Southern Cone) have been attributed to differences in achieved levels of equality (Lindegarde and Tylecote 1999). Development is not possible if extreme inequality is present, if accumulation of knowledge and innovation capabilities are not enhanced, and if the search for more equality is divorced from innovation. That lesson stems not only from the past but from the present: "Some of the most highly visible globalization 'success stories' — including China and India — are failing to convert wealth creation and rising incomes into more rapid decline in child mortality. Deep-rooted human development inequality is at the heart of the problem" (UNDP 2005c, p. 4).

Latin America has been and continues to be the most unequal region of the world. Recent statements by the Director of ECLAC, the Economic Commission for Latin America and the Caribbean, indicate that inequality has defeated all efforts to diminish it, compromised the fight against poverty, and fragmented society to such an extent that democracy is at stake. In a well-known paper by Fernando Fajnzylber (1990), Latin American countries were classified as follows: those in which high inequality is combined with fast or slow growth (Brazil is an example of the first situation, Ecuador and Paraguay of the second) and countries in which inequality is lower than the region average, but where growth is slow (e.g., Uruguay). It is not possible to find, then or now, countries in which fast growth is combined with low or diminishing inequality. Given that the last combination opens the road for a sustainable process of development, the negative characterization made by Fajnzylber is particularly telling: rapid growth with low inequality is the "empty cell" of Latin American development. It continues to be an empty cell for large regions in Africa and Asia. However, it has not been empty in some development process, such as those followed in South Asia and in Scandinavia. Persistent inequality is by no means the unavoidable companion of economic growth.

Lasting improvement of equality cannot be achieved by assistance-type social policies alone: even if they are extremely necessary, they are not enough. Social policies must also help to enhance capacities to do new things, to integrate new technologies into everyday life, and to solve problems by making the most extensive use of knowledge. Equality emerging from these processes can be called *proactive equality* (Arocena and Sutz 2003) because, by fostering equality and innovative capabilities at the same time, they pave the way to virtuous circles for lasting and even increasing equality.

The enhancement of market mechanisms, which has been accompanied by weakening of public-sphere intervention during the last 25 years in Latin America, has, as the Director of ECLAC stated, not been able to diminish inequality. Public policies are needed to move toward filling the empty cell of development and fostering proactive types of equality. However, their effectiveness will depend on their legitimacy and systemic scope. Social policies enjoy high legitimacy in Latin America; they could profit from local innovation to fulfill many of their aims. Can social policies provide an adequate "policy umbrella" to foster the intertwined processes of increasing both equality and innovation? Yes, because:

- Innovation must become strongly valued to be able to enhance proactive equality.
- Accumulation of capabilities is a key to innovation — stronger and better articulated National Systems of Innovation are needed to protect and foster these capabilities and, for this too, innovation must become strongly valued.
- A high level of legitimacy is needed in the realm of related public actions.
- The gap between discourses, actions, and outcomes in relation to innovation in Latin America can be attributed (even if not exclusively) to the inability to think of innovation as a national priority and as a tool for articulating social actors.
- Innovation has not enjoyed political legitimacy, and therefore has not been strongly valued, either politically or culturally.

We have come full-circle. A new round of working hypotheses follows:

- The legitimacy of actions that will assure that innovation will be consequently fostered will be found in a realm that enjoys legitimacy itself.
- In Latin America — as well as in developing countries in general — social policies are a realm that enjoys high and visible legitimacy.
- Linking innovation to the demands that stem from social policies can:
    - extend the legitimacy of social policies to innovation policies;
    - promote that accumulation of knowledge and productive capabilities can be achieved in a wide array of productive sectors; and
    - foster proactive equality.

This paper develops these working hypotheses in four sections.

Section 1 is a general introduction. It addresses the dilemma that expanding Science, Technology and Innovation (STI) often does not favour, or even harms, the less favoured. It also analyzes the gap, at the world level, between increases in STI achievements and increases in inequality. In this context, the working hypothesis are refined.

Section 2 revisits the issue of development strategies. Concepts and indicators are presented to characterize underdevelopment in the light of the new reality of a "globalized knowledge economy." It is argued that, even if investing in STI is absolutely necessary for development, the actual results are often neither impressive nor evenly distributed among the whole population; thus, justifications and orientations for developmental STI policies need to be revised. This leads to a discussion of some clues for a "new development" that is intimately related to the democratization processes. A general framework for policies is presented, which includes "building blocks" and specific mechanisms. This framework takes into account the most pressing current needs in developing countries and presents some concrete ways to address them. As an example, the costs of implementing some mechanisms in a concrete case are estimated.

Section 3 addresses the main concern of the paper, the integration of innovation policies and social policies. The idea that a more direct link between STI and the needs of the poor is both needed and achievable through deliberate policy efforts is discussed in the context of Amartya Sen's and Albert Hirschman's approaches to development. Concrete examples show how innovation policies can be derived from social demand. Problems and possibilities are

considered within the realm of the life sciences and the recent experience of Uruguay, where a new government assigned maximum priority to a program for overcoming extreme poverty.

In section 4, recommendations are presented. The basic assumption is that IDRC wants the Innovation, Policy, and Science Program to have a focus on innovation policies as social policies. The fulfillment of this aim requires that new issues are integrated into the research agenda. Strategies and examples are presented to show how this can be done.

To conclude this presentation, we want to stress that we do not believe that science and technological innovation can be the main clue for solving social problems. “One-fifth of humanity live in countries where many people think nothing of spending $2 a day on a cappucino. Another fifth of humanity survive on less than $1 a day and live in countries where children die for want of a simple anti-mosquito bednet” (UNDP 2005c, p. 3). No scientific or technological tool will fix such an outrageous situation. Above all, social problems require social solutions: economic, institutional and political issues must be addressed. If that is done with energy and creativity, innovation policies can help.

## 1. Innovation and Inequality

It is often said that destitution and extreme poverty is the problem, not inequality. Even if equality is not considered a value, inequality matters, particularly because of its impact on poverty:

> First, more equal societies have less poverty. The burden of support for the nonelderly poor is therefore less, and the political controversies surrounding the notion of aid to the undeserving tend not to arise. The social problems of the poor tend to be seen much more as the social problems of the temporarily poor - a category in which many people can imagine themselves falling, for example, through loss of employment. Thus, there is greater and wider support for what is, in any event, a smaller and less onerous burden. Transfer programs themselves can then be generous enough to blur the distinction between the poor and the middle class, and the stigma of poverty falls away.
>
> Second, more equal societies have fewer rich people. In a society of broadly based equality, the proportion of those opting out of public services, of those for whom public pension plans are financially insignificant, becomes a politically negligible fringe. But as society polarizes, the rich develop an ethos all their own- an ethos of exaggerated individualism, of independence from the state and rejection of public institutions (Galbraith 2000, p.15).

When such is the situation, using knowledge for human development is really difficult. The Human Development Report 2005 is particularly concerned with the Millennium Development Goals (MDGs). Its presentation states: "Extreme inequality between countries and within countries is identified as one of the main barriers to human development — and as a powerful brake on accelerated progress towards the MDGs."

### 1.1 The Dilemma of Science, Technology, and Innovation

Science, Technology, and Innovation (STI) are key for development. Here development is understood as *human self-sustainable development*, characterized as a process that betters the quality of human life today by means that are environmentally sustainable and expand the collective capabilities that will allow further progress tomorrow. Development cannot be reduced to economic development, but the last is necessary for the former. Economic development can be seen as the combination of an expanding production with its upgrading, that is, of economic growth and innovation. Thus STI must play a key role in the economic aspects of development as well as in its social and environmental aspects.
However, in highly unequal societies it cannot be taken for granted that a strong effort in STI will be evenly distributed among the whole population, or even that it will contribute to a self-sustainable development process.

Diffusion of innovations more often than not favours social groups already favoured:

> …diffusion researchers have not paid much attention to the consequences of innovation. They have been specially inattentive to the issue of how the socio-economic benefits of innovations are distributed within a social system. When the issue of inequality has been investigated, we often find that the diffusion of innovations widens the socioeconomic gap between the higher an the lower status segment of a system (Rogers 1995, p.125).
>
> When a system's structure is already very unequal, it is likely that when an innovation is introduced (specially if it is a relatively high cost innovation) the consequences will lead to even greater inequality in the form of wider socioeconomic gaps (Rogers 1995, p. 436).

The trend toward higher inequality is probably stronger in a global knowledge-based and innovation-driven economy, where a *generalized Matthew effect* seems to hold. Broadly speaking, people with greater capabilities, power, and social capital are better situated to innovate, to take profit from innovations, and to learn by innovating. That trend fosters economic growth in the North but not necessarily in the South, where it can hamper social cohesion, and thus pose a major problem for good governance.

More than half a century ago Latin American development scholars studied the "structural heterogeneity" of underdeveloped economies, where a modern sector concentrated technical progress while a large part of the population was relegated to a backward sector. This present duality in South Africa is described by President Mbeki (as quoted by the GLOBELICS 2005 Call for Papers) when he speaks of the "First Economy," modern and integrated to the global economy, and the "Second Economy, or the Marginalized Economy." Innovation tends to be concentrated in the First Economy and thus widens the gap that separates it from the Second Economy. Also with South Africa in mind, Lorentzen (2004, p. 10) noted that "in highly unequal or dualist societies, business-science relations contribute at best to isolated pockets of excellence." As a consequence, often a social gap and even conflicts appear between, on the one hand, the small group of innovating firms, research groups connected with them and related decision makers, and, on the other hand, social movements and organizations fighting against marginalization.

This divergence has been evident in different editions of the World Social Forum, where modern science and technology have been explicitly rejected precisely because it was said that they were widening the gap between the haves and the have-nots. Only the free software movement was hailed as keeping the promise of science and technology for the good of everyone. In the same vein, a hot debate started around the idea, put forward first in South Africa and then expanded to the whole continent, that occidental science was in fact enslaving African people, who should only rely on their own science (scidev.net, first week of March 2006).[3]

In any case, a disturbing trend has been detected in the world at large: "Income inequality is increasing in countries that account for more than 80% of the world's population" (UNDP 2005c, p. 6). Reactions against such a trend are often akin to what Albert Hirschman called the "tunnel effect" — the temporary tolerance to the inequality provoked by the diffusion of any kind of well being in some track of society and not in another. For some time, people tolerate the immediate growth of inequality because they expect that the restrictions that hamper their participation in the goods that are unevenly distributed will be removed. But as times goes by and they continue to perceive that they are left behind, tolerance vanishes. Hirschman (1981, p. 58) uses a telling metaphor: tolerance to inequality is like credit that has an expiration date.

The frequent divorce between fostering innovation and searching for more equality is a crucial problem for many regions of the South. Development is not possible if extreme inequality is present, or if accumulation of knowledge and innovation capabilities is not enhanced.

[3] In the same issue, another article argues that the introduction of GMO (genetically modified organisms) in Latin America, particularly the queen of seeds, soyabean, has ended with the impoverishment of small farmers. The point to be stressed is that consequences in terms of inequality are one of the main criticisms to the application of modern science and technology in developing countries.

Addressing the latter problem by promoting STI in the South frequently does not solve the former problem, and sometimes it even aggravates it, which in turn hampers capability building in society at large. **This is a central dilemma for policies**.

## 1.2 The STI & Inequality Gap

In the world at large there is a striking contrast between increased scientific, technological, and innovations capabilities and increasing inequalities that cause persistent suffering.

> "The era of globalization has been marked by dramatic advances in technology, trade and investment – and an impressive increase in prosperity. Gains in human development have been less impressive. Large parts of the developing world are being left behind. Human development gaps between rich and poor countries, already large, are widening. Meanwhile, some of the countries most widely cited as examples of globalization 'success stories' are finding it hard to convert rising prosperity into human development. Progress in reducing child mortality, one of the most basic of human development indicators, is slowing, and the child death gap between rich and poor countries is widening. For all the highly visible achievements, the reach of globalization and scientific advance falls far short of ending the unnecessary suffering, debilitating diseases and death from preventable illnesses that blight the lives of the world's poor people" (UNDP 2005c, p. 19).

There is a real gap between STI and inequality — the *STI & I gap*. Several aspects of this gap were highlighted in a Workshop on *Science, Technology, and Inequalities: Effective Policies and Programs*, organized in February 2005 by the American Association for the Advancement of Science (Cozzens and Nelson, forthcoming). Two of those aspects are briefly mentioned here.[4]

One aspect is the *research agenda component* of the STI & I gap, that is, the biases of the world R&D agenda. It concerns the big problems that are not the object of active and well-founded research because there is no market pull for them. Its relevance is forcefully stressed by the so-called "neglected" or "under-researched" diseases. An estimate by Médecins sans Frontières shows that from 1975 to 1999 "only 15 new drugs were developed for tropical diseases, while 179 new drugs were developed for cardiovascular diseases in the same period" (Thorsteinsdóttir et al. 2004b, p. 4). In addition, 50% of the world expenditure in health-related research is done by the United States; whereas, the developing world without China accounts for 6% of the expenditure (Michael Free 2005, oral presentation at the Seminar *Innovation Systems Theory. Application to Diseases of the Poor*). There is a "scientific failure" concerning many problems affecting deprived populations, of which health problems acquire special pre-eminence. This scientific failure has its roots in market considerations. When, after extensive consultation with African health officials, a Meningitis Vaccine Project was defined to get an affordable meningitis conjugate vaccine at a price not higher than one dollar the dose, no multinational manufacturers where interested in participating (Morel et al. 2005, p. 8). A PPP (public–private partnership) between WHO (World Health Organization) and PATH (Program for Appropriate Technology in Health) with an innovative manufacturer of a developing country did the job (Morel et al. 2005).

The issue of under-researched diseases belongs to a category of problems that Mahmoud Fathalla of the WHO calls "*diseases of the poor*." These problems provide an example of the *research agenda component* of the STI & I gap. He categorizes another type of health-related

[4] In the introductory remarks, a question that captures the uneasiness that the STI & I gap is causing was posed: "Why is it that we are doing better in STI and we are feeling worse?"

problems, labeled "*diseases and the poor*," which are derived from the impossibility of relying on existing technical solutions because they are too expensive, because the existent infrastructure cannot assure their proper conservation, use, and distribution, and even because of cultural factors. These examples constitute the second aspect of the STI & I gap: its *access component*. It includes problems for which solutions exist, but are out of reach for the deprived populations, mainly for cost reasons.

These problems can be seen as a scientific and technological failure or, more accurately, as an innovation failure. This way of understanding the second component of the gap is not trivial. If the gap is conceptualized only as an access failure and not as an innovation failure, the search for solutions can be reasonably directed to finding ways to provide financial assistance to developing countries so they can buy the existing drugs, treatments, and medical equipment. That is of course of paramount importance, as it is stressed by the following assertion: "Providing basic health-care coverage in a low-income country costs an estimated $30 – $40 per capita. Across much of Africa spending is less than $6 per capita" (UNDP 2005c, p. 63). If the gap is also seen as an innovation challenge, national and international financial resources can be channelled to innovative approaches that lead to different heuristics in the strategies for problem-solving. This can lead, on the one hand, to cheaper solutions that allow a much broader coverage, thus diminishing inequality — a striking example is the Cuban vaccine against Hib. On the other hand, this approach can enhance innovation capabilities in developing countries, thus opening the way to further progress. The combination of those two potential effects exemplifies the notion of proactive equality.

Here is a schematic way to sketch the STI & I gap and to suggest how integrated innovation and social policies could help in narrowing this gap.

| | Problems included in main stream research agendas | Problems not included in main stream research agendas |
|---|---|---|
| Adequate solutions for the majority of citizens in developing countries | I<br>Solutions acquired through imports or other forms of technology transfer | II<br>Results of local innovation efforts (e.g., small units to obtain drinkable water) |
| Inadequate solutions for the majority of citizens in developing countries (for many reasons, including cost) | III<br>"Diseases and the poor," the access component of the STI &I gap (e.g., non affordable vaccines) | IV<br>"Diseases of the poor," the agenda component of the STI & I gap (e.g., under- researched diseases) |

Source: Adapted from Srinivas and Sutz (2005).

Cells II, III, and IV are part of the STI & I gap. In Cell II, local innovation efforts are able to narrow the gap through adequate solutions: the results are examples of innovations driven by social needs. Such innovation efforts have positive social impact not only because pressing needs are solved, but because they foster learning processes that enhance the capacities to solve other problems. They are examples of proactive equality efforts. Cells III and IV contain huge social demands for innovation that stem from heavy unequal situations. Many of these demands require first rate research; some are probably well beyond the solving capabilities of any single country,

calling for the strengthening of international cooperation. Advances along the road toward proactive equality can be expected from such cooperation.

**What we have termed the STI dilemma and the STI & I gap both strongly suggest that innovation policies themselves should address the issue of inequality.**

### 1.3 The pursuit of proactive equality

We do not assume that STI can be a modern Saint George that will defeat the dragon of inequality and poverty. For that, a broad range of social changes are needed. In fact, in the classical Latin American approach to the underdevelopment issue, development was conceptualized as an overall social transformation.

In this paper, child mortality is mentioned several times. We must stress that daunting aspects of that issue cannot be addressed by STI policies. For example, in China "research indicates that child mortality rates are rising at 0.5% a year for girls while falling at 2.3% a year for boys" (UNDP 2005c, p. 63). That requires a cultural and political fight: "Reducing gender inequality would have a catalytic effect on cutting child deaths. That effect would be especially pronounced in South Asia, where gender inequality is most deeply entrenched" (UNDP 2005c, p. 62).

The worsening of the health situation of poor people is a frequent consequence of general economic and political processes. That has been, for example, the consequence of some privatization processes, even in countries where economic growth is remarkable.

> "Charging for basic health-care increases inequality. Payments for health care can represent a large share of the income of poor people, leading to reduced demand, uncompleted treatments or increased debt. In Viet Nam a single hospital visit costs 40% of the monthly income of people in the poorest 20% of the population. High levels of household health spending not only deter use of services, but by one estimate have pushed 3 million people in Viet Nam into poverty. In China the erosion of the public health system after the economic reforms of the late 1970s has exacerbated inequalities in health [...] Today, China spends 5% of GDP on health, which is relatively high for countries at comparable levels of income, but public spending on health amounts to less than 2% of GDP. In effect, health financing has been privatized. [...] average per capita spending on health in urban areas is now 3.5 times the level in rural areas. Between 70% and 80% of the rural population have no health insurance coverage" (UNDP 2005c, p. 63).

Human self-sustainable development has many aspects. One of them — surely not the most relevant, but not negligible — is connected with the orientation of STI efforts. In this sense, the guiding thread or conjecture of this paper is that concrete and feasible ways of coping with several problems in underdeveloped regions are highlighted when innovation policies are directly connected with attention to the most pressing social needs. Of course, innovation should be concerned not only with social needs but, as previously stressed, with the different but interconnected aspects of development.

Now, development is not only an issue of policies but fundamentally one of politics. In particular, learning and innovation policies must be implemented effectively and with a systemic scope, but that is not enough. Actual results also depend on the social legitimacy of innovation and its place in the political agenda, the conflicts in priorities, and the possibilities of building coalitions oriented toward proactive equality. In Latin America, after the poor social

consequences of economic and institutional policies inspired by the recommendations of the "Washington Consensus," social policies enjoy high legitimacy. In fact, they seem to constitute — in the view of the international financial community — the only really legitimate realm for public spending. Social policies could profit from local innovation to fulfill many of their aims, which would provide an adequate "policy umbrella" for stronger capability building efforts. Strengthened capabilities would in turn enhance development in general. Perhaps the same is true in many other regions of the South.

Two closely related assumptions underlie this view. First, to fight inequality, it is necessary, but not sufficient, to redistribute the fruits of growth. This may be akin to seeing people as patients rather than agents, while the essence of development is precisely the opposite (Sen 2000). Second, innovation efforts should be oriented not only to attend to the needs of the poor but also to expand their own capabilities. Successful development trajectories are characterized by different ways of promoting *proactive equality*. They are characterized as those ways of diminishing inequality that are positively correlated with increases in collective capabilities for learning and innovation.[5]

Finland and South Korea are recent and very successful examples of Human Development. Their innovation capabilities are widely admired. It is also known that they are comparatively quite egalitarian countries. For example, the ratio of incomes of the richest 20% of the population to the poorest 20% is 26.4 in Brazil, 10.4 in Uruguay, 8.4 in USA, 4.7 in South Korea, and 3.8 in Finland. Inequality is considered high when the Gini index is above 50. The Gini coefficient for the whole world is 67. It is 59.3 in Brazil, 44.6 in Uruguay, 40.8 in USA, 31.6 in South Korea, and 26.9 in Finland (UNDP 2005c). Qualitative studies confirm what quantitative data suggest: both Finland and South Korea fostered innovation and diminished inequality in such a way that each process favoured the other.

Our guiding conjecture can thus be rephrased as follows: linking innovation closer to the demands that stem from social policies may help (1) to overcome pressing needs, thus (2) making innovation more strongly valued in society at large and, moreover, (3) enhancing knowledge and productive capabilities in a wide array of productive sectors located in the "Second Economy", so (4) social cohesion and human development can be fostered.

**In short, the integration of innovation policies and social policies may provide a way to pursue proactive equality.**

[5] "In a nutshell, *proactive equality* refers to the different processes that, by diminishing inequality in ways that enhance collective learning and innovation capabilities, enable further economic and social progress, while *reactive or defensive equity* lacks such potential, in the sense that it diminishes inequality in ways that do not foster or even hamper innovation capabilities, so in general it is not a self sustainable process" (Arocena and Sutz 2006).

## 2. On Development Strategies

To explore the possibilities for integrating innovation policies and social policies in underdeveloped regions, a first step is to revisit the problem of development strategies.

### 2.1 Underdevelopment in the Age of the Knowledge Economy

Underdevelopment has shown a particularly strong capacity for resistance, which is illustrated by some familiar numbers. The GDP per capita (measured in PPP (parity of purchasing power) in USD] in 2003 was on average 1.328 in least developed countries, 4.359 in developing countries, 7.404 in Latin America and the Caribbean, and 30.181 in high-income OECD countries (UNDP 2005c). Life expectancy at birth in 2000–2005 was 52.0 years in least developed countries, 64.9 in developing countries, 64.9 and 71.7 in Latin America and the Caribbean, and 78.8 in high-income OECD countries.

The return of "poverty illnesses" such as tuberculosis, which were heralded as having disappeared, is one of the many examples of the stubbornness of underdevelopment. However, although the manifestations are old, the underlying causes are both old and new. If the phenomenon of underdevelopment includes both manifestations and causes, then underdevelopment today is, in an important sense, a new underdevelopment.

Both globalization and knowledge are involved because of their renewed power to divide. Strongly intertwined, both aggravate one of the most fundamental divides of our time: people who have advanced capacities and opportunities to work in creative and learning environments, and people who do not have such capacities and opportunities. The macro figures of this divide are well known. For example: although about 80% of the world's population lives in developing countries, less than 20% of the world expenditure in R&D is spent in those countries and less than 30% of all researchers live there; developed countries have ten times more researchers per million inhabitants than developing countries; and the difference in terms of gross expenditure in R&D per capita is even wider (UNESCO 2001). The educational aspect of this divide is not less eloquent: "On average, a child born in Mozambique today can anticipate four years of formal education. One born in France will receive 15 years at vastly higher levels of provision" (UNDP 2005c, p. 24).

Something new is happening in higher education. In fact, two new things are happening: (1) for the first time in history higher education is not any more a privilege of minorities in developed countries; and (2) the "enrollment gap" in higher education has been widening between North and South (Figure 1).

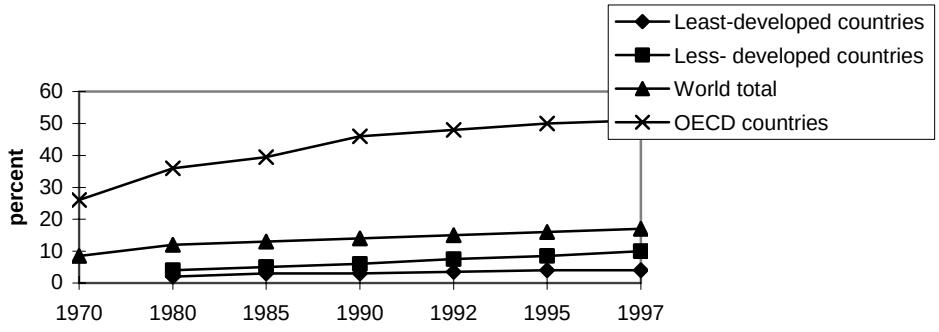


**Figure 1.** Gross enrollment in tertiary education (1970–1997) by income group (World Bank 2002, p. 46).

The combination of low spending in R&D and low tertiary education enrollment in the South, and high spending in R&D and high tertiary education enrollment in the North, can be sketched in a pair of Cartesians axes (Figure 2).[6]

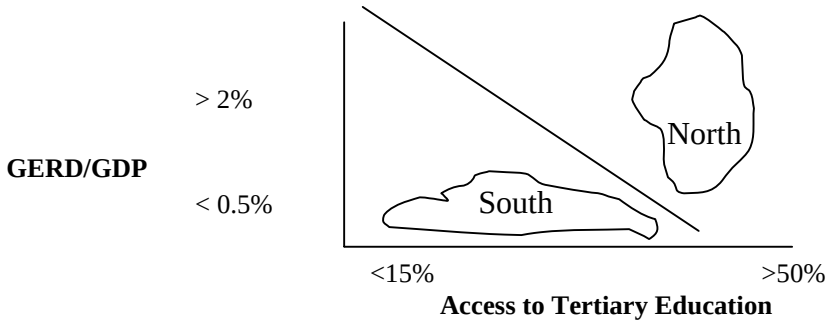


**Figure 2.** Cartesian representation of spending on R&D and enrolment in tertiary eduction.

The line separating North and South in Figure 2 can be called a "learning divide" (Arocena and Sutz 2000), and it can be used to characterize underdevelopment in the age of the knowledge economy.

Below the learning divide, knowledgeable people find it hard to put to good use what they have learnt. This is because in global terms the investment in R&D is low, and because participation by the business sector in that investment is tiny. In the North, business investment in R&D is at least 1.5 times that of government; however, in developing countries government investment is about four times higher than business investment. In the South, researchers concentrate in the

[6] In Latin America, two polar situations appear. One is Argentina, with universal access to higher education but less than 0.5% of GERD/GDP; the other is Brazil, that recently reached the threshold of 1% of GERD/GDP but where higher education is a model of elitist access. The "North" instead exhibits a much more equal situation, where even countries that spend in R&D less that the OECD average and are in the limit of what is considered acceptable, are nonetheless well positioned in relation to higher education. (GERD = gross expenditure on research and development.)

university sector with extremely weak participation in the business sector. Although the distances in terms of access to higher education in the North and in the South are important, **even more important and difficult to redress are the differences in opportunities to locally apply knowledge to the resolution of local problems**.

All this is a strong driver of brain drain. The nuances around brain gain and brain circulation notwithstanding, plain brain drain continues to be a severe flaw in Africa and Latin America (Meyer 2003).[7] The reasons are many, but one in particular should not be underestimated: the frustration of not finding a place at home to apply knowledge to solve problems that can make a difference in developmental terms. This feature has been explicitly acknowledged in brain-recuperation strategies in East Asian countries (Song 2003). Brain drain and under-use of local capacities go hand in hand.

What are the relations between the former indicators of underdevelopment in the globalizing knowledge economy and the situation of the poor? What instruments can social policies implement to open opportunities for knowledgeable people to put their capacities at the service of their most deprived fellow citizens? Each question deserves many answers. Choosing only one for the first question: relatively few researchers, working with little money, crowded in the academic milieu for lack of opportunities in the business sector (even to start their own firms) and without significant demand from the state or the market, will find it difficult to lead innovative research initiatives related to the problems of the poor. In solitude, they probably will not even be aware of them. This paves the way to answer the second question: if social policies are articulated with science, technology and innovation efforts, particularly to provide information on problems, that is, play the role of the demand side, and assure the diffusion of the solutions, the first result will probably be a significant intellectual mobilization. Helping knowledgeable people to be socially helpful through knowledge can be a non-trivial step toward crossing the learning divide.

## 2.2 Investing in STI in the South[8]

The increased relevance of knowledge recommends higher public investing in STI in developing countries. But that option is not without problems. It competes for usually scarce resources with very pressing social needs. As previously stressed, innovation frequently favors those who are not the less privileged.[9] And, moreover, investing in STI has not always been very efficient for development purposes.

Recent trends toward the privatization of knowledge compound this problem. The convenience of such process can be contested in theoretical terms (Nelson and Romer 1996). Nevertheless, if the main benefits stemming from STI are privately appropriated, then the justification for public investment in that area should be reconsidered.

[7] The total number of researchers from developing countries is approximately 1.600.000, of which 400.000 work in USA, Europe and Japan (Pellegrino, 2004: 52–53).
[8] A more detailed discussion of the topics in this subsection is presented in Arocena and Sutz (2005).
[9] This may be the case even in highly industrialized countries. Analyzing the case of the United States, Galbraith (2000, p. 205) writes: "Although there is surely a role in general terms for science and technology policy under liberal governments, these policies do not bring about a fairer and more just social order. The immediate effect of more rapid technological change is just the opposite: to increase disparities across the social spectrum."

Of course, there is no example of successful development, at least in the last two centuries, that is not associated with strong public investment in STI. Rich countries became rich while expanding their research and innovation capabilities. Today they are expanding their investment in STI not only in absolute terms but also in relation to their production. A relevant proportion of this investment is public because the social return of this investment is in many cases greater than its private return (Schonfield 1981). The experience of the North shows that the efficiency of STI efforts is highly dependent on learning processes, at the individual level, in organizations, and in society as a whole (Cohen and Levinthal 1990; Lundvall and Borrás 1997; Archibugi and Lundvall 2002).

The relevance of learning is one of the main reasons why developing countries cannot efficiently use available knowledge without building endogenous STI capabilities. To avoid the "low road" of unacceptable labour and environmental standards, R&D and, in general "domestic technological efforts", are critical (UNIDO 2003). Without these efforts, as well as relevant investment in education and training, little can be obtained by importing technologies (Freeman 2002). In fact, "technological capabilities cannot be transferred quickly and without cost along with equipment, blueprints and user manuals. It has to be built up through purposive 'technological efforts': investment in time and resources aimed at assimilating, adapting and improving known technologies, and (ultimately) creating new technologies in-house" (Caniëls and Romijn 2004, p. 39). Science itself plays an important role in development processes from their very beginning as a "source of absorptive capability and provider of public knowledge for the productive sector" (Bernardes and Albuquerque 2003, p. 874).

International organizations are now recognizing that knowledge is a key component of development processes, and country-models like Finland begin to be put forward. However, the deep reasons behind the Finish success have been somehow obscured or at least simplified, as was the case a decade ago with South Korea. "A knowledge-based growth strategy" was a focus of the transformation that occurred in the early nineties in Finland: the answer to the important economic crisis of these years was to push R&D, and not to consider it a luxury. Accompanying this, was a great effort to increase and diversify the university system. However, Finland more often than not is presented as the Nokia success, the ICT success, the road to wealth and growth through innovation in new technologies. This is a road that quite obviously most developing countries are not able to follow. The conclusion, even if frequently tacit, is that if the high-technology road is out of reach, then a knowledge-based growth strategy is simply out of order and scarce resources should not be devoted to science, technology, and innovation and advanced education.

This conclusion should not be dismissed easily in countries where social needs are extraordinarily pressing. Advocating that more attention should be paid to STI and advanced education should be rooted in internal reasons, not in dubious bench-marking. These internal reasons exist and are quite strong. They relate to different types of important economic and social problems that can be solved only if local capabilities in science and technology are put to the task. Some successful examples from Uruguay will be mentioned, but similar examples can be found in any developing country:

- Different types of cattle diseases have a severe impact on the Uruguayan economy; some of these diseases have been eradicated or have no incidence in developed countries;

vaccines or other treatments must be developed locally; this cannot be done without first rate virology research; the joint efforts of a veterinarian laboratory and a university research group led to several of such solutions.

- Uruguay is a wool exporter; the productivity of the industrial part of the wool production depends heavily on the degree of automation of the washing process; the cost of the imported equipment is high and the machines available in the market are not quite adequate; the joint efforts of a technology-based firm and a university research group lead to a successful special-purpose machine, that was later exported separately.
- The harvests of oranges and other fruits are at stake in Uruguay due to sudden frosts; the methodology available to deal with frosts is inadequate for the country's conditions because it was designed for much more severe conditions and is consequently unnecessarily expensive; a university researcher designed a very original solution for local frosts, that was tested for use also in some regions of France and Italy.

These examples are outcomes of investments made in science and technology in particular and in education in general. Having the right people to deal with complex problems that cannot be solved with off-the-shelf solutions is the outcome of long-term investments; having these people is crucial for development processes. Public investment in STI is thus very important in the South, probably even more important than in the North, particularly because private investment is usually extremely small and much riskier.

However, experience shows that investing is not sufficient to upgrade learning processes and capabilities, particularly when the amount of investment will surely be modest in absolute terms. **How to invest in STI emerges as a decisive question.**

### 2.3 A New Development as Democratization

Investing in STI for development requires some guiding ideas concerning what is needed to overcome underdevelopment in the age of the knowledge economy. This is an immense challenge, and these tentative formulations are focussed on Latin America.

From the 1950s to the 1970s, the most influential conceptualizations assigned to the state the central role in developmental processes — and the results were mixed. A great ideological and political shift in the 1980s and 1990s led to a notion of the market as the demiurge of development — and the results were not impressive. As a consequence, the idea of development itself lost a great deal of its public and even academic relevance.

Even more worrisome are the consequences for democracy of such a state of affairs:

> "Since the beginning of the 1990s, income distribution in the region overall has not improved, nor has the total number of poor people declined; furthermore, levels of unemployment were higher in the mid-1990s than they had been at the end of the 1980s. Such levels of decline, distress, and suffering cannot persist indefinitely without gravely damaging democratic institutions and norms" (Diamond et al. 1999, p. 61).

Development strategies have not been very successful in most cases; the problems posed by the "underdeveloped condition" are even more complex due to the new role of knowledge; new strategies are needed to cope with new divides. We must think in terms of a New Development.

States and markets are undoubtedly necessary for development. That is aserted both by the National Systems of Innovation (NSI) approach and the classic Latin American thinking about science, technology, development, and dependence (Sabato 1975). But both approaches go beyond the sterile contraposition between state and market, and focus their attention on the interactions between several collective actors and organizations — e.g., governments, firms, academy, users, and trade unions. This emphasis on interactions stresses what Hirschman (1958) started teaching almost half a century ago — the evolution of backward and forward linkages is a main indicator of development. The most successful developmental experiences of the last century also suggest to focus on actors and linkages. Thus, going beyond the state-centered approach to development that was dominant until the 1970s and the now still dominant market-centered approach , an *actors-centered approach to development* emerges. That is our starting point.

This idea is closely connected with Sen's celebrated conception of development as the expansion of capabilities and freedoms. An actors-centered approach to development highlights both individual and collective capabilities. If this view is correct, we may be facing a great problem in the world at large:

> For most of the past 40 years human capabilities have been gradually converging. From a low base, developing countries as a group have been catching up with rich countries in such areas as life expectancy, child mortality and literacy. A worrying aspect of human development today is that the overall rate of convergence is slowing — and for a large group of countries divergence is becoming the order of the day (UNDP 2005c, p. 25).

Perhaps this worrying aspect of development is related with what we call the generalized Matthew effect. Knowledge is a resource that, unlike material resources, is expanded and not diminished when it is used, so those who are capable of using more knowledge are precisely those whose knowledge expands most.

Underdevelopment is characterized by comparatively weak capabilities and, even more, by largely underutilized capabilities. Hirschman also taught that the main task for development is to find those potential capabilities that are hidden, fragmented, or wasted, and to put them to work for developmental purposes. It follows that a fundamental task is to detect and protect *infant capabilities*. These capabilities need specific support to grow, which includes fostering a high-level demand for them, and thus providing opportunities for expansion-by-use of capabilities.

From this perspective, a New Development must be built on three pillars:

- First, an economic pillar — upgrading the knowledge content as well as the learning and problem-solving capabilities for producing goods and services, in every sector, not only in the "high tech" sectors but also in the more or less "traditional" ones.
- Second, a public policy pillar — enabling the State to play an active and flexible role in articulating what different actors do or can do, a task that includes the incorporation into development processes of frequently neglected social groups; all this usually requires a thorough transformation of the State itself.
- Third, an educational (or cultural) pillar — promoting advanced and generalized life-long learning, closely connected with work; if such an aim is not taken as a fundamental priority, the enrollment gap and even more the learning divide will grow.

The three "pillars" are interconnected and the three exemplify the notion of proactive equality. Those assertions are elaborated elsewhere (Arocena and Sutz 2006). We only want to add two remarks, one related to democracy and the other to the present socioeconomic situation of Latin America.

***Democracy in Latin America***

After the end of many successful transitions from dictatorships to democracy in the 1980s and early 1990s, many democratically elected governments were almost completely incapable of ameliorating the situation of the have-nots. That lack of relevance of democracy to poverty and inequality endangered democracy itself. Several political scientists reached conclusions of the following type (which, by the way, are easy to believe): "there is a powerful tension, if not a negative correlation, between inequality and democracy in Latin America" (Diamond et al. 1999, p. 48). The causal link behind this correlation is not hard to grasp. Democracy is ultimately about the distribution and control of social power, about having a not too unequal influence on what concerns us most. The issue of *agency*, fundamental for Sen (2000), is also central here. When inequality is high — concerning educational levels, relations with the State, and productive capabilities — many are not able to behave as agents, be it as citizens or as producers. When inequality is very high, democratically elected governments can sometimes afford to neglect a large proportion of the have-nots, which are seen not even as patients. Is it strange that, in such cases, many surveys show that a majority would prefer a non-democratic government if "it solves people's problems"?

Because knowledge is power more than ever, people are worried about their educational perspectives and those of their children. Many are ready to become agents in this realm if opportunities are opened for widening and improving access to different types of advanced education connected with working possibilities. This in itself is a democratizing process.

Incorporating knowledge and problem-solving capabilities into different productive sectors may also be a democratizing process, particularly if traditional sectors are included, because more people are empowered to have a say in their own work and the asymmetries of power between different collective actors may be diminished. [10]

Last but not least, when the State, instead of just "deciding" what should be done, operates as an effective articulator of different actors, incorporates weak sectors, and advances social concerns in the STI agenda, agency is fostered and inequalities may be lessened.

Summing-up, the "three pillars of a New Development" can be seen as extensions of democracy to the realms of economies, public policies, and education.[11]

[10] This view is akin to the *democratization of technology* characterized as "pursuing open and transparent processes that involve all concerned stakeholders" (Isnor 2005, p.4), which "in the South has become a prominent and often controversial issue of research and policy attention, even more so than in many developed countries, due to the ever-widening knowledge divides between North and South [...]" (Isnor 2005, p.7).

[11] The approach summarized in the last two paragraphs is elaborated in Arocena (2004, 2005).

***A window of opportunity?***

The second remark concerns the recent evolution of Latin America and current trends. Roughly speaking, looking for new strategies for development with a long-term framework is difficult both in good times and in bad times. During a crisis — the "lost decade" of the 1980s or the "lost half decade 1997–2002," in ECLAC's terms — daily survival is what counts, for people, firms, or governments. When prosperity seems assured — as many believed it in the early 1990s — who will listen to calls for change? Perhaps today there is a transient window of opportunity because the situation is far from being good — and everyone knows it — but almost all foresight exercises say that the actual period of growth will continue for several years.

Poverty and indigence are simply appalling in Latin America:

> "As a result of the very low growth rate registered for the region's per capita GDP in 2003, poverty and indigence indices for that year appear to have edged up to 44.3% and 19.6%, respectively. Stronger growth in 2004 should lead to a reduction in the poverty rate for the year of somewhat more than one percentage point, however. Accordingly, the poverty rate ought to amount to 42.9%, while the indigence rate is expected to come in at 18.6%. These changes are likely to be insufficient to offset population growth during this period, however, so no reduction in the number of poor or indigent people relative to 2002 is to be expected. The number of poor people is estimated at 222 million and the number of indigents at 96 million" (ECLAC 2004, p. 18). Some data indicate "that the countries have been converging towards a higher level of distributive inequity" since 1990 (ECLAC 2004, p.22).

The situation looks a little bit better now than when these statements were written near the end of 2003. A few months ago it was asserted that the "Latin American and Caribbean economy grew by 4.3% in 2005 [...] and poverty indices decreased from 44% in 2002 to 40.6% in 2005". Moreover: "For 2006, GDP growth for Latin America and the Caribbean is projected to come in about 4.1%; this rate would be high enough to bring about an annual average growth above 4% during 2003-2006 and an accumulated growth of 11% in per capita GDP" (ECLAC 2005).

In the developing world as a whole, economic growth has been on average accelerating for several years:

> "Average per capita income growth in developing countries in the 1990s was 1.5%, almost three times the rate in the 1980s. Since 2000, average per capita income growth in developing countries has increased to 3.4% - double the average for high-income countries. After two decades of declining average income, Sub-Saharan Africa has posted an increase of 1.2% a year since 2000" (UNDP 2005c, p. 20).

More importantly, most predictions point to the continuity of growth. There is an oppprtunity for combining an increasing production with the upgrading of its knowledge content and the betterment of the unacceptable social situation. This should be an opportune time to put forward new initiatives for a **New Development**.

## 2.4 A Framework for Policies

This section proposes some answers to the question: How should we invest in STI policies? These answers are inspired by the issues highlighted earlier, by the just sketched approach to a New Development and, in particular, by Hirschman's idea that underdevelopment is a result of the sub-utilization of existing capacities.

**Table 1.** A summary of the framework that provides the building blocks of innovation policies and offers list (certainly not exhaustive) of instruments or mechanisms that correspond to each block.

| **Strengthening learning possibilities** | **Enhancing knowledge demands** | **Promoting articulations and linkages** | **Fostering STI involvements and consensus** | **The prospective dimension** |
|---|---|---|---|---|
| Betterment of general S&T education<br><br>Under-graduate fellowships and training<br><br>National post-graduate programs<br><br>“Sandwich” post-graduate studies<br><br>Graduates and post-graduates follow-up<br><br>Mobility programs<br><br>Connections with the S&T Diaspora<br><br>Supporting research groups | STI in social emergency programs<br><br>Knowledge demand of the public sphere<br><br>Technological public procurement<br><br>Technological court of appeal<br><br>STI extensionism | Promotion of innovative circuits<br><br>Joint academy-production projects<br><br>Projects involving national high-tech firms<br><br>Advice for small firms and trade unions<br><br>Stages of advanced students in SME | Interactive and mobile S&T museums<br><br>Divulging national STI achievements<br><br>STI civil service of students<br><br>STI journalism<br><br>People’s perceptions of STI<br><br>Citizen’s participation in STI decisions | Center of STI foresight for development<br><br>Technological foresight of public demand<br><br>Foresight exercises with multiple actors<br><br>Wide public diffusion of foresight results |

### *First building block: strengthening learning capabilities*

This block aims to improve the quality of education in general and to find ways to generalize different types of permanent advanced education, which are closely connected with knowledge-demanding working activities.

A concrete instrument related with proactive social policies is the betterment of general scientific and technological education. This can be implemented through cooperation of researchers with primary and secondary level teachers. It is not easy to assume that senior researchers would be able to work on a long-term basis on such a task, but that is not necessary and perhaps not even desirable. What is needed is a first carefully planned experience, where not only researchers and teachers but also university students participate. What is done and learned in such a pilot project could act as a “multiplier” of different experiences in which university students cooperate with primary and secondary schools. This can be a relevant example of the "civil service” of university students, which should be one of the main components of a socially and developmentally oriented “third mission” of universities.

Other aspects deserve attention. A project to support the local development of some didactic tools for the experimental teaching of science and technology could have the double effect of

providing what is needed at a low cost and fostering the emergence of a small specialized industry. It offers a wide scope for innovation and experimentation. In Uruguay, the cost of such a pilot project has been estimated to be a little more than USD200,000.

### *Second building block: enhancing knowledge demand*

People who poses knowledge — basic knowledge, science-based technological knowledge, practical technological knowledge, skills in general — must be able to apply what they know to problem solving activities. In the Scandinavian countries, highly successful technological innovations have been related with welfare-state activities (Gregersen 1988).

A fundamental instrument in this case is to include a science, technology, and innovation dimension in programs that address social urgencies. Two aspects must be covered at an initial stage:

- Detecting the scientific and technological demand that stems from such programs — if for example, three teams of well-trained people worked for 6 months in connection with those charged with the implementation of an emergency plan in housing, nutrition, and health, the estimated cost in Uruguay would be USD60,000.
- Elaborating and financing proposals that are able to achieve the goals posed by the detected demand — in Uruguay, based on past experiences, it could be expected that about 50 projects per year would be elaborated that would combine scientific and technological excellence, social relevance, and a fair possibility of implementing the results. The total cost for a period of five years (including a thorough ex-ante and ex-post evaluation) would be about USD6.5 million for the ensemble of projects.

Not only poor people benefit less than they should from STI. Small and medium enterprises (SMEs) are in the same situation. In Uruguay, for example, although 80% of firms with more than 100 employees have at least one professional with a scientific or technological background within their working force, only 20% of SMEs are in such a situation. SMEs are very important in economic terms, given that they usually comprise the majority of business firms in developing countries; they are also very important in social terms. Enhancing their demand for STI can foster modernization “from below,” which fosters a slow but significant move to socio-technical inclusion. The set of instruments associated with this type of effort can be called “technological extensionism.” One such instrument consists in fostering technological awareness among SME. This requires personalized attention, particularly to technology-weak firms; but can open opportunities for local capabilities to solve problems through cooperation among firms. This instrument, whose main actors can be young professionals or researchers, consists of “technological missions” to work for a year with a firm to detect problems and find institutions, public or private, that are able to cooperate in solving the problems. The estimated cost of each mission is USD12,000 a year.

### *Third building block: promoting articulations and linkages*

A relevant example of linkages is given by *innovative circuits*, which are started when an actor with a problem meets an actor who has knowledge that can help solve that problem. The solution can be found if the circuit works, that is, if both actors are able to communicate and combine their knowledge.

Here are two examples of innovative circuits in Uruguay. The first example is in alternative and effective energy and links a top engineering group in fluid mechanics with a group of countryside women producing high quality cooking herbs. The women needed cheap and reliable sources of energy in the remote places where they live. In the words of the engineer in charge of the project, it was the extraordinary capacity of these women to express what they wanted to obtain that explains the success achieved. A second example is connected with the Biomedical Engineering Group: the innovative circuit in this case was established with a firm that manufactures pacemakers around the design of a semi-custom chip with specific features that allowed the devise to be miniaturized.

Promoting linkages implies promoting the idea that technology can be useful, accessible, and affordable. A good instrument for that is to provide systematic technical advice to very small firms, cooperatives, trade unions, local movements, and other collective actors who usually lack the knowledge needed to be active partners — that is, agents, not patients, as Sen (2000) would say — in innovative circuits and linkages.[12] A "Technological Advice Office" with this objective would be useful both in itself and as a signal or flag for socially oriented innovation policies. Costs would obviously depend on the investments that governments are willing and able to make in this area. In Uruguay it has been estimated that some positive results could be achieved with only USD30,000 a year.

***Fourth building block: fostering involvement and consensus on innovation issues***

This is a key aspect of proactive equality. Public perception of science, technology, and innovation is related to social cohesion. People may have proactive or reactive attitudes toward them depending on whether their preferences are taken on board when related decisions are made. If that is the case and people know this is the way things happen, we may expect that innovation will be more socially driven and that the citizenry will be more inclined to back investment in the expansion of innovative capabilities. Moreover, to be aware of the issues at stake, people also need to know about possibilities and national capabilities.

For this purpose, interactive S&T museums and mobile expositions are useful, particularly to reach people who are disconnected from higher-education and research centres. Such a network of museums and expositions exists in Latin America. It has been calculated, for example, that USD30,000 a year could greatly empower the Uruguayan component of such network.

Another concrete instrument would be to study public perceptions of science and technology to allow decision-makers to take into account people's priorities, hopes, and fears regarding new knowledge and how it is being used. It would be useful to undertake, once every 5 years, a national survey and focused study on such issues. In Uruguay that would cost about USD50,000.

Promoting citizen's participation in decisions concerning innovation priorities and conflicts is not easy. Different international experiences can be inspiring, but no attempt to import them should be made. Experimentation will be needed to devise concrete ways that are adapted to the specific cultural and political contexts. Journalists could greatly help. A necessary condition is

[12] In Uruguay, an initiative by the metal workers trade-union resulted in the creation, 20 years ago, of a Commission on New Technologies, which brought together workers and university researchers to analyze the best ways and means to introduce new technologies to industry. "New technologies, new alliances" was the motto of the initiative, which aim was to establish more systematic "knowledge contacts" between workers and researchers.

that decision-makers and researchers are willing to foster public participation in what is often seen as a matter that only concern experts.

### *Fifth building block: anticipation, seeking a long-term prospective*

The aim is to prepare today to cope with fundamental issues of tomorrow. The lack of prospective usually leads to not preparing the ground for what will come to be mandatory technologies. Related signals stem from different sources, including some that anticipate future social needs (e.g., demographic trends). Prospective exercises should be systematic and involve several actors, including politicians, public officials, entrepreneurs, educators, researchers, journalists, representatives of trade unions, cooperatives, and NGOs. Prospective activities may also help promote linkages and proactive collective attitudes.

To assure a permanent effort in this direction, a Centre of STI Foresight in Development should be put in place with the mandate to conduct different types of prospective exercises and ensure wide diffusion of the results. This initiative needs a permanent structure, but not a costly one: about USD60,000 a year would be needed in a country like Uruguay.

## 3. Integration of Innovation Policies and Social Policies

### 3.1 Some tools for achieving integration

Effective innovation policies include the ability to foster linkages and interrelationships among different actors, so that each of them can profit from a distributed supply of diverse capacities. The "systems of innovation" approach is particularly useful in the design of effective innovation policies precisely because it insists on the importance of actors, institutions, and their mutual relations. In this way, it helps to identify the wide range of people and organizations involved in innovation, their demands and aims, the capabilities they have, the weaknesses they present, and the type of conflicting and cooperative relationships they maintain in society as a whole. This coverage is a fundamental step for the subsequent mapping of existing and missing linkages between such actors and organizations, and a useful guiding thread for policy design.

One result of the successful application of policies inspired by the systems of innovation approach is the enhancement of the actual system of innovation at the national, regional, or local level. In underdevelopment, the extreme fragility of national systems of innovations — if we can really talk about the existence of innovation systems — makes the design of effective policies particularly difficult, which in turn jeopardizes overcoming this fragility. These difficulties notwithstanding, the systems of innovation approach, if the local context is properly taken into account, is extremely useful in developing countries, where the sparse innovative fabric makes it even more important to identify actors and linkages.

This approach, precisely because it is "actor-centered," can be a precious analytical tool to devise innovation policies that are integrated with social policies. A first step toward this aim is to build a combined and sophisticated view of both the ensemble of people, needs, organizations, and values involved in social demands, and the existing innovative capabilities to fulfill these needs and build linkages that may bridge the two. The identification of actors is particularly difficult because we not only have different kinds of deprived people but different kinds of organizations that act on behalf of such people. The identification of the linkages inside the "social arena" and between this realm and the "knowledge and innovation arena" is no less difficult.

If one of the aims of innovation policies in the long term is to achieve stronger and better articulated national systems of innovation (NSI), the integration of innovation and social policies points to the emergence of socially oriented NSI. Such a system of innovation would help to put the innovation at the service of the ensemble of social demands and take into account the different parts of the system. The marks of a socially oriented NSI should be seen in the government's technology procurement policy[13], in the setting of academic research agendas, in

[13] In fact, government technology procurement has been conceptualized both as a demand side policy and as a socially oriented policy: "A central role ... of Government Technology Procurement is to articulate demand. Hence the state agencies serve as sophisticated customers. They take societal problems and needs as their point of departure. However, scientific and technological progress is a necessity to solve the problems and satisfy the needs being focused upon." (Edquist and Hommer, 1998: 17). A Swedish example of GTP directed towards the common good in environmental terms was the technical definition of a refrigerator: "An example of the NUTEK activity in energy-saving is the procurement of new refrigerators in the early 1990's. The requirement was that much less freon – which damages the atmosphere's ozone layer - should be used in production and that the refrigerator's energy use should be considerably lower than with earlier designs. A bidding contest was announced where the prize was an

the university reward system, and in the incentives for the formation of knowledge-based firms. New institutions are needed, particularly those related to the systematic identification of social demands and the translation of these demands into innovation projects. However, new activities in existing institutions are also needed, for example in the financial system to give support for the development of such projects. The social impact of introduced innovation must be monitored, and the requisites for a more even profitability from innovations, mainly in the field of education, should be carefully understood and implemented. [14]

Endogenous innovation is often a vulnerable process in developing countries; socially oriented innovations, or innovations that can be more important in social terms than in regard to other considerations, will probably be at least as vulnerable.[15] We have suggested the idea of *gardening policies* as an orientation — or inspiration — for innovation policies in underdevelopment (Arocena and Sutz 2004). That idea leads to the five building blocks of innovation policies previously described. A good gardener detects, protects and promotes the best plants of his garden; in the garden of innovation, that means building efficient tools for (1) strengthening learning possibilities and (2) enhancing knowledge demand. The search for ecological compatibility in the garden leads to (3) promoting articulations and linkages. Taking the whole garden into account means (4) fostering STI involvements and consensus. Anticipating future problems and opportunities for the garden is (5) the prospective dimension of STI policies.

This idea of gardening policies can be even more fruitful when related to the integration of social and innovation policies. Three aspects should be considered.
First, it is important to avoid "de-learning" processes in socially oriented innovation — that is, failures to accumulate capacities to identify social demand and to conduct innovations to satisfy this demand.[16] Concrete experiences of this type are particularly fragile: "gardening-type"

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order of at least 500 refrigerators - which went to the company which could satisfy the demands. (...) This example illustrates clearly that innovation policy through technology procurement can have other objectives besides economic ones; in this case the goal was environmental." (Ibid: 16)

[14] "The faster the pace of innovation, the greater the risk of social exclusion *as a result of technology development*… This argues for continuing emphasis on the cohesion issue and continuing pressure for policies that not only redistribute resources and provide the hardware for infrastructure improvement, but also pay attention to the necessary software improvements. In other words, roads, bridges, even telecom infrastructures are not enough: investment in human capital is just as, if not more, important" (Sharp 2002, p. 242). In a similar vein, writing about "Social Exclusion in the Learning Economy," Schienstock (2002, p. 74) asserts that "traditional innovation policy aiming at encouraging major technological breakthroughs seems to be less effective in creating a great number of new jobs." If this holds for Europe, to which the authors refer, it holds even more strongly in underdevelopment.

[15] An example of the latter was the national production of recombinant insulin by a Brazilian firm, based on its own patent. The social importance of the process innovation underlying this production lies in the high number of insulin-dependents in Brazil, mostly poor people. The assurance of the supply of this pharmaceutical specialty to the health authority at affordable prices is key in social terms, something that failed to happen in other Latin American countries. However, social relevance was not taken into account when a decision to dismiss the local firm as provider in a bid organized by the Ministry of Health led to the decision to sell it to a multinational pharmaceutical firm (Sutz 2005).

[16] The concept of "de-learning" was introduced in Arocena&Sutz, 2000. It was first presented in 1999, and after two rounds of discussions it became clear that it was a wording easily associated with "forgeting" and with "unlearning", both concepts carrying a positive meaning that "de-learning" was not intended to have. The clarification is perhaps worth to recall: "It is important to rapidly state that the concept of de-learning has nothing in common with that of forgetting, in the way Johnson presents it: 'It is possible that the role of forgetting in the development of new knowledge has been underestimated. The enormous power of habits of thought in the economy constitutes a permanent risk for blocking potentially fertile learning processes.' (Johnson, 1992, p. 29). De-learning

policies are always aware that fragile species must be protected. Many examples can be given to illustrate the need for understanding innovation policies as gardening policies, particularly to avoid "de-learning" situations. Two of such situations, stemming from the Uruguayan situation, relate to telecomunications and biotechnology. The first is the story of a long process of knowledge and know-how accumulation, initiated in the mid sixties in the University and continued during the seventies in high-tech start-ups. The concrete product of such accumulation was the design and production of small, modullar and digital telex systems, something that did not exist at that time in the market. The social importance of this local design was that it provided an affordable state-of-the-art solution for the export efforts of many SME enterprises that were not able to rely on the very expensive telephone system. At that time the fax system was not yet invented. The learning accumulation went to an almost stop when in the mid eighties the digitalization of the telephone systems was bought turn-key to a foreign company without any participation allowed for local firms. Gardening policies would have meant to realize that such participation was to be included in the terms of the public bid. The second example relates to a very efficient vaccine against the foot-and-mouth desease -a main problem in all cattle zones in South America- developed during the eighties by a local small biology based veterinarian firm. The success of the learning process of this firm can be exemplified firstly by the fact that it was selected by Bolivia to conduct the campaign against the desease, and secondly because it was declared by the European system of biosafety assessment as one of the three firms in the Southern Cone region fulfilling the biosafety standards. Uruguay was declared free of the foot-and-mouth desease with vaccination in the early nineties. Thanks in part to the quality of this locally adapted vaccine no upsurges appeared in the following years, particularly because due to some technical features of the vaccines even small and poor producers were able to apply it. The country was declared in the mid-nineties free of the desease without vaccination. At that very moment the de-learning process occurred: the government, based on an ancient law passed when no biosafety existed, banned the manipulation of the living virus of the desease, putting a halt to the local produccion of the vaccine. A gardening policy should have avoided the closing of the biotechnology branch of the firm, that was what ocurred.

A second step  in gardedning policies is to go from protecting to supporting new undertakings. Policies that are specifically aimed at linking social issues to innovation projects, and incorporating these policies into general policies that are concerned with the importance of such linkages, must be invented. This means that a great deal of sophisticated policy development is needed, based in historical traditions and present conditions. New possibilities and potentials of each "garden" deserve great attention.

For Amarya Sen, development is best seen as an expansion of people's 'capabilities' (Sen 1984, p. 510). This "perspective can be used not just for evaluating equality, but also for assessing

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is not a way of forgetting, understood as a way to make room for new thoughts. Nor is it to be confounded with the concept of unlearning, as Loasby puts it: 'Successful change may not be easy. There are always costs of switching to a new cognitive system, especially when the switching entails the creation of new linkages with other people's cognitive systems that are simultaneously being restructured; every well-established organisation has its own familiar institutions, which may have become almost part of its identity. Unlearning can be both cognitive and emotionally difficult.' (Loasby, 2000, p.13) De-learning is a 'pure loss': it is not intended to anything, it is just made to happen, without even giving a second thought about its consequences. De-learning is the Sisyphus legend of the development process, a phenomenon hard to recognise in the 'centre' but nevertheless real, and serious indeed." (Arocena&Sutz, 2000: 21)

efficiency" (Sen 1995, p. 143), because "freedoms are not only the primary ends of development, they are also among its principal means" (Sen 2000, p. 10).

Such approaches suggest, as a third step, a "bottom-up" strategy. The starting point is given by the links, synergy, or circuits that connect social demand to innovation that really exists. They should be considered as lessons, stemming from society itself, about how to integrate social concerns with innovation initiatives in the usually less than friendly context of developing countries. They need to be thoroughly identified; they deserve the care a gardener gives to flowers.

A socially oriented national system of innovation can be seen to be formed, from below, by the multiplication and interconnection of concrete experiences that blend social concern with innovative efforts. Thus, *detecting, protecting, and promoting* such efforts seems to be a central chapter and a good starting point for "gardener type" efforts to conceive *STI + Social policies*.

### 3.2 Bioinnovation and Inequalities

Innovation based on life sciences and related biological problems (i.e., bioinnovation) is increasingly relevant. It also illustrates the wide possibilities, strong conflicts, and worrying gaps that can stem from innovation processes. Bioinnovation is thus a main area for STI + Social policies aimed at diminishing the STI & Inequality gap.

***Possibilities***

The potential contributions of biotechnologies to achieving the Millennium Development Goals (MDG) are impressive (UNDP 2005a). The report of the Genomics Working Group of the University of Toronto Joint Center for Bioethics, entitled Genomics and Global Health, describes carefully the kind of problems for which the search for solutions could profit from biotechnology approaches. That report insists that bioinnovation is not a magic recipe that will redress, for example, the millions of children that die each year before their fifth birthday, which is one among many pressing health and nutrition problems affecting developing countries. What the report does is identify how bioinnovation can be one tool in the fight against such extreme forms of inequality. It identifies ten biotechnologies with especially strong possibilities to address such problems. Five of them are listed and very briefly explained in Table 2.

Table 2. Five of the ten biotechnologies that have been identified to help achieve the MDGs.

| | |
|---|---|
| **Molecular diagnosis** | "… once disease strikes, diagnosis and treatment methods are essential. Molecular diagnostics are simple to use, give quick results and can be relatively cheap" (Joint Centre for Bioethics 2004, p. 16). For example: African sleeping sickness; and Nicaraguan multiple test for *Leishmania*. |
| **Recombinant vaccines** | "… may prove to be cheaper than traditional vaccines because of innovative production methods and, in some cases, because improved storage characteristics may not require them to be refrigerated" (Joint Centre for Bioethics 2004, p. 20). This field is more a promise than real fact up to now, but progress in clinical trials is being made in malaria and tuberculosis. Cuba is working with these techniques in dengue and cholera. The promise has been fulfilled in the case of hepatitis B. In India, where 1% of all adults deaths are due to hepatitis B and more than 40 million people are carriers of the disease, a locally developed recombinant vaccine was available for USD0.50; whereas, previous imported vaccines had cost USD16 per dose (Thorsteinnsdóttir et al. 2004a, p. 19; Kumar et al. 2004, p. 34). |
| **Vaccine and drug delivery** | "… logistics of vaccine delivery are prohibitively expensive. The 'cold chain' is a major expense in all vaccine programs. Unsanitary drug and vaccine injections are associated with blood-borne diseases. Injection-free and controlled-release delivery can help to solve many of these problems" (Joint Centre for Bioethics 2004, p. 22). For example (in developmental stage): inhalable skin patch and powdered vaccines. |
| **Bioremediation** | "Bioremediation is the use of bacteria or plants to clean up the environment" (Joint Centre for Bioethics 2004, p.23). A Uruguayan example (ongoing): Children living in some poor neighborhoods in Montevideo are affected by heavy lead contamination, with consequences for their intellectual abilities. Contamination is concentrated in the soil and a strategy of bioremediation through specific plants to remove the lead is being followed at the Faculty of Sciences. A massive water arsenic poisoning process in Bangladesh may be addressed by means of this technique, using a bacteria discovered in Australia, currently under research and trial. |
| **Recombinant therapeutic proteins** | "Therapeutic proteins, such as insulin, are used to treat many non-communicable diseases." Current trends suggest that these diseases will account for more than 70% of deaths in developing countries by 2020. "Affordable and sustainable sources of therapeutic proteins for treating these diseases are therefore critical." (Joint Centre for Bioethics 2004, p. 33) Recombinant insulin is up to now the greatest achievement of this technique. Its importance derives from the illness it helps to control, diabetes, which affects 33 million people in South America, 30 million in India, and is expected to rise at the world level up to 300 million in 2025. Brazil in the late 1990s and India in 2003 patented their own recombinant insulin, after sustained R&D and commercial efforts. |

The case of insulin is particularly telling in terms of how endogenous bioinnovation efforts can redress the problem of no access to technical solutions that are not affordable. In the case of Egypt, where about 10% of the population is affected by diabetes, "before the start of local production, over 90% of the country's total insulin needs were imported from one multinational company at a cost of USD 35 million annually to the government. Today, local firms have the ability to manufacture by recombinant means sufficient quantities of affordable insulin" (Abdelgafar et al. 2004, p. 25).

Other techniques mentioned in the Genomics and Global Health report and connected with the achievement of the MDGs are bioinformatics and combinatorial chemistry. These are techniques that can greatly accelerate the discovery of useful drugs. In South Africa, for example, a bioinformatics spin-off company from the University of Western Cape "makes software for

processing and analyzing mRNA and expressed sequence tag data, and this platform has already been exploited, for example, in drug target discovery in trypanosomes" (Motari et al. 2004, p. 19). Combinatorial chemistry is so important that *Médecins sans Frontières* (Doctors without Borders) rely on it for its Drugs for Neglected Diseases Initiative, which aims to create portfolios of new drugs for some of these diseases (Joint Centre for Bioethics 2004, p. 36).

***Conflicts and alternatives***

Bioinnovation also provides relevant examples that even non-military innovation is not necessarily a good thing for everybody and that innovation processes may increasingly lead to conflict. Therefore, the issue is not only one of policies but also of politics.

Conflicts connected with bioinnovation often means that grass-root activists may oppose actual innovation processes (Parayil 2003). Such movements often have good cause, as for example, when Monsanto gave up the commercialization of "terminator" seeds. If more evidence is needed to show how bioinnovation is related to politics, good examples are available from the discussions around who is entitled to make decisions on issues involving the manipulation of life and what knowledge should be used to make these decisions. That is seen in the case of Germany's conflict over biotechnology in the mid 1990s:

> Civil servants and scientists tends to follow a traditional approach, claiming that their actions are based only on the law and putatively objective knowledge. They presume that there is only one correct interpretation of the law and one 'rational' solution. Hence, they can respond to objection only by blaming the objectors for 'irrationality'… When objectors are labeled as irrational, they react angrily. As a normal counter-reaction, administrative and industrial experts make their safety claims even more precise and restrict the public discussion to technical issues. The more precise the claims, however, the more easily they can be rejected by counter-expertise, or even contradicted by factual events… Other objectors are cognitively excluded and emotionally frustrated by the narrowing battle over expertise…Thus the dominant legitimization style in Germany perpetuates the original conflicts, as the GMO issue illustrates. The problem is not that there is a conflict but that there are no compromises, nor even meaningful dialogues" (Gill 1996, p. 179).

Ten years later, political problems derived from "styles of legitimization" like the one just described can be seen everywhere. For example, an environmental conflict has escalated into a political and economic conflict between Uruguay and Argentina, two neighbors with close and traditionally good relations. The Finish firm BOTNIA and the Spanish firm ENCE are building cellulose plants in the Uruguayan side of the river (also called Uruguay) that separates these countries. For Uruguay, it is the most important investment in the country's history; its government asserts that no significant environmental perturbation will be caused and that all the monitoring measures will be in place. In Argentina, some groups claim that the plants are going to pollute the Uruguay River beyond all acceptable standards, and as a protest they have blocked the main bridges that connect the two countries. The Government of Argentina backs that claim. The economy of Uruguay has already been noticeably damaged. Up to now (April 2006) it has not been possible to organize an independent and technically qualified assessment that is acceptable to both governments. Each of them has strong public opinion support in their respective countries.

The absence of "meaningful dialogues" concerning environmental, technical, and economic aspects of relevant productive projects is seen not only within, but between countries, and can have dangerous consequences.

Can rational dialogues and broad participation by civil society help find legitimate and efficient solutions to such issues? Or, due to the complexity of modern knowledge and the importance of economic issues, are such alternatives merely rhetorical?

In Finland, for example, early TA (technology assessment) exercises were largely seen as 'speaking truth to the power' exercises; whereas, more recent TA studies have increasingly encompassed objectives related to 'generating dialogues' and 'mobilizing common learning processes' (Salo and Kuusi 2001, p. 460). In the case of environmental issues in Denmark, "most proposals from the authorities are submitted to various interested groups, such as industry and NGOs, thus providing opportunities for them to influence decisions at an early stage" (Toft 1996, p. 174).

As with many other issues, this one is related in a fairly direct way to social cohesion and mutual social trust. This aspect has been neglected more often than not by those promoting big techno-productive changes in Latin America. For example, biotechnologies are often introduced in agriculture as an imposition to local producers. They serve the expansion of big capital in agriculture and foster inequality, social conflicts, and lack of trust in technological innovation. Better results are obtained when local knowledge and opinions are taken into account. This is a striking illustration of the notion of proactive equality, and shows how we might shape innovation policies as social policies.

Bunders developed a methodology to achieve what she calls "the interactive bottom-up approach." This approach aims to overcome the lack of interaction and exchange of information that hampers effective decision-making on biotechnology that is directed to improving the conditions of small and poor farmers. Many studies on the often disappointing results of bioinnovation for such actors have been made, and all type of inadequacies have been identified. "The most critical obstacle to success in the generation and adoption of new technologies would appear to be the absence of communication and cooperation between the various groups and types of people whose contributions are essential: farmers, scientists, policy makers, extensionists, and others such as the private sector" (Bunders 1994, p. 154). It is particularly difficult to recognize and to take into account what end-users already know: "it is necessary to pay more and systematic attention to the method of identifying problems of small-scale farmers, of the interests and the political power of the different groups involved, and of assessing the appropriateness, feasibility and sustainability of the perceived biotechnological solution. The 'interactive bottom-up approach' is designed to meet these criteria; to avoid technology-push and to include the opinions and organize the support of not only scientists but also that of end-users and the organization that represent/and/or work with them" (Bunders 1994, p. 163). Research is only one step in the complex process of wedding knowledge to development, but it is a very important one. However, research is a concept that conveys various meanings and implies different attitudes, many of which are not appropriate for the delivery of useful results for development processes. Bunders (1994, p. 158) proposes a beautiful and challenging phrasing: "Research has to be the handmaiden of development."

### *Narrowing the STI & I gap*

At a world lever, bioinnovation plays a major role in the STI & I gap. However, it can also help to narrow this gap, not only because it is related with fundamental problems of people in

developing countries but because its cognitive support is relatively stronger in the South compared with other disciplines.

Here are several examples from Latin America:

- Health sciences make up a majority of existing research groups: Brazil (41.5% of all groups), Colombia (30.1%), and Uruguay (40.7%). (CNPq, Relevamiento de Grupos de Pesquisa 2002; COLCIENCIAS 2002; Unidad Académica de CSIC 2003).
- 60% of all basic research done in the region is in the realm of biology (Cetto and Vessuri 1998).
- In the promotional schemes for researchers implemented in the region, biologists rank very high (e.g., Uruguay 63% and Venezuela 72% in 2001).
- Biology is the best represented discipline in terms of its contribution to world science measured by publications in Argentina and Mexico, and also ranks very high in Brazil. Two other countries in which this situation appears are Australia and Canada. (Fapesp 2002, p. 6).
- Life sciences are also the more internationally recognized of Latin American research achievements, as illustrated the three Argentinean Nobel Prizes in chemistry and medicine — the only Nobel Prizes in sciences in the region.[17] An impressive Brazilian achievement — to be the first country to decode the genome of a plant pathogen (attacking citrus fruits) in 2000 — is another example of the international impact of the regional capabilities in life sciences.

Bioinnovation presents a great opportunity for development purposes. A striking example of the application of an innovation potential to social problems is the Cuban vaccine against *Haemophilus influenzae* type b. It shows how one aspect of the STI & I gap can be narrowed by opening to poor people the health opportunities that were previously reserved for rich people.

The anecdote surrounding the Cuban initiative to develop an affordable vaccine against the bacteria of *Haemophilus influenzae* type b (Hib) starts with a visit of a member of the Cuban government to Canada in the 1980s. Being a pediatrician professionally, he asked to visit centres for intensive pediatric care. He was surprised by the fact that these centres were really large and were being clearly underutilized. The reason for the size of the centers was Hib, a illness that targets children under 5 years of age, exhibits high mortality, and often has severe sequels in case of survival. The reason why these centres were underutilized was that a vaccine against Hib had been recently developed in the United States, and had dramatically dropped the incidence of the illness. The cost of the vaccine, produced by biological methods (fermentation) was not affordable to any public health campaign in a poor country — it was certainly not affordable for Cuba. However, Cuba had reason to believe that the cognitive base of the country was strong enough to take the risk of looking for a different way to get an efficient and cheap vaccine. The meningitis B Cuban vaccine, developed by means of endogenous R&D in the 1980s, was the first in the world of its kind. Fifteen years of research, development, and clinical trials lead to the development of the first synthetic vaccine. Its efficiency was proven, a million vaccines doses

[17] Bernardo Houssay got his Nobel Prize in Medicine and Physiology in 1947. His research was triggered by the discovery of insulin and relates to the pituitary gland. Luis Federico Leloir got his Nobel Prize in Chemistry in 1970. His work was associated to the metabolism of sugar related compounds. César Milstein got his Nobel Prize in Medicine and Physiology in 1984, a shared prize for his contributions to the development of monoclonal antibodies.

were applied to Cuban children around two months of life in 2004, and the scientific breakthrough was published in Science in the same year. Here is the abstract of that paper:

> Glycoconjugate vaccines provide effective prophylaxis against bacterial infections. To date, however, no commercial vaccine has been available in which the key carbohydrate antigens are produced synthetically. We describe the large-scale synthesis, pharmaceutical development, and clinical evaluation of a conjugate vaccine composed of a synthetic capsular polysaccharide antigen of *Haemophilus influenzae* type b (Hib). The vaccine was evaluated in clinical trials in Cuba and showed long-term protective antibody titers that compared favorably to licensed products prepared with the Hib polysaccharide extracted from bacteria. This demonstrates that access to synthetic complex carbohydrate–based vaccines is feasible and provides a basis for further development of similar approaches for other human pathogens (Vérez-Bencomo et al. 2004).[18]

The practical importance of this breakthrough is the low production cost of the vaccine, given the synthetic procedure used to "build" the antigen. It is expected that this synthetic vaccine will help to redress the gap between 600,000 children dying from Hib in developing countries and no children having the illness in rich countries (Kayser 2004). Moreover, the team to which this result is due are considering the possible extensions of the synthetic procedure to build low cost vaccines for other illness (Vérez- Bencomo, conference at the Workshop "University, Science and Technology", Havana, February 2006).

It is worth recalling that the MDG target of reducing child deaths by two-thirds will be missed by a wide margin based on current trends. Two interrelated factors explain much of the deficit. First, "... in most countries the poor account for a far larger share of child deaths than is commensurate with their share of the population" and second, "the rate of child mortality is falling much more slowly among the poor than the average rate of decline in most countries" (UNDP 2005c, p. 61).

The case of the low cost Hib vaccine is an outstanding example of narrowing the STI & I gap, but by no means an isolated one. The study of *trypanosome cruzi*, the agent responsible for the Chagas illness — an important cause of death for poor people in the countryside — is intensively researched in outstanding institutes in Brazil and Argentina, FioCruz in Rio de Janeiro and Campomar Foundation and the Institute of Genetic Engineering and Biotechnology in Buenos Aires. This research has greatly contributed to the understanding and prevention of the illness. The Brazilian Butantan Institute, with its wealth of serums and vaccines against different illnesses, including tetanus and diphtheria, has made a great contribution to public health in its country.

Uruguay also provides an example of the accumulation of technological learning and production capabilities that have had an impact on public health services: electronic pacemakers. In 1960, the world's first successful under-the-skin pacemaker implantation was performed in Uruguay, where the demand for pacemakers was important given the incidence of cardiovascular illnesses. At that time, pacemakers were produced in very small batches; most devices were imported and very expensive; and, because of the cost, their use was severely limited. In 1969, the cardiologist who performed the first implantation established a firm to design and produce pacemakers at low

[18] This vaccine jointly developed with a research team in the University of Ottawa is a good example of the blending of innovation in its Shumpeterian meaning with social concerns: it received in 2005 two international prizes, the WIPO Gold Medal, after passing the first patent, and the Technology Museum for Innovation Award, for technology benefiting humanity.

cost. This was a difficult issue given that pacemakers are life-support devices and, therefore, technical tests are especially complex and rigorous. The commercial survival of the firm in its initial stage relates to a public health policy of guaranteeing a pacemaker to everybody in need of it irrespective of his/her capacity to pay for it. A special public fund was established for that purpose. This policy instrument did not act as technology procurement by the government because medical doctors could buy or recommend any pacemaker, locally manufactured or imported. But the good quality and significantly lower price of local pacemakers allow the firm to hold a fair share of the internal market. Learning processes and accumulation of knowledge and capabilities led the way to exports to almost every country in Latin America and the Caribbean as well as to Iran, Hungary, Greece, and Italy. Uruguay is still the only developing country producing pacemakers of its own design.

At a broader scale, "60% of UNICEF's vaccine requirements for the Expanded Program of Immunization (EPI) are produced in just four countries: India, Indonesia, Cuba and Brazil. Thailand obtains 90% of its antiretroviral (ARV) ingredients from India, while the three South Africans producers of ARV obtain 100% of their raw materials from India" (Morel et al. 2005, p. 7).

**Table 3.** Lessons learned from case studies (Source: Thorsteindóttir et al. 2004c, p.50).

| | |
|---|---|
| **Brazil** | • Focus on developing strong science capacity<br>• Promote linkages and exploit existing strengths in disparate fields<br>• Exploit biodiversity for health<br>• Gain access to key actors |
| **China** | • Provide long-term government support<br>• Attract expatriate professionals<br>• Ensure that biotechnology development goes hand-in-hand with regulations<br>• Leverage large population base |
| **Cuba** | • Ensure long-term government vision and policy coherence<br>• Promote domestic integration to spur innovation<br>• Capitalize on internal linkages<br>• Tap into national pride |
| **Egypt** | • Focus on health needs<br>• Gain access to key actors<br>• Take advantage of international linkages |
| **India** | • Leverage strengths when cultivating linkages<br>• Meet international standards<br>• Use competitive advantage<br>• Pay attention to the regulatory environment |
| **South Africa** | • Focus government policy on public health needs<br>• Exploit both indigenous knowledge and science-based innovations<br>• Develop local R&D infrastructure for self-reliance |
| **South Korea** | • Create a mix of small and large firms<br>• Exploit existing competitive advantages<br>• Go global |

Many more examples of biotechnological prowess with the potential to have a significant impact on the quality of life of poor people can be found in a special issue of Nature Biotechnology (December 2004). This issue contains the results of a 3-year research project on health-biotechnology innovation in several developing countries. The lessons learned during this project are worth quoting (Table 3).

## 3.3 Social Emergence and Innovation in Uruguay

Uruguay is a good case study for "testing" our leading conjecture: when innovation policies are directly connected to the most pressing social needs, it is possible to find concrete and feasible ways of overcoming the frequent divorce between fostering innovation and searching for more equality. The country is also a good case for relating this conjecture to bioinnovation. Uruguay has developed quite strong research and innovative capabilities related to, or used for, life sciences that can be of direct application to social aims. A new progressive government took office in 2005, and its main project is PANES, *Programa de Atención Nacional a la Emergencia Social* or National Program for the Attention of Social Emergency (in Spanish, PANES is the plural of PAN, which means BREAD).

Uruguay is one of the countries with a high human development index according to UNDP reports: during the 1990s it ranked between 34 and 40, and fell to 46 in 2002 (UNDP 2005b, p. 41). However, the economic crisis suffered in 2002 has aggravated the level of poverty, which reached 40.8% of the population in 2004. The Uruguayan situation has been characterized as "infant poverty" because children constitute the most deprived sector in terms of income: in 2004, 65.1% of children 0–5 years and 62.9% of children 6–12 years were below the poverty line; whereas, 18% of people aged 65 and more were in poverty (UNDP 2005b, p. 101).

The government is committed to backing science, technology, and innovation, which have been officially neglected up to now. A connection between social and STI aims at the policy level seems to be emerging, even if it is too early to provide any hard evidence. Some of these connections have existed for a long time, but, given the weak structure of the Uruguayan innovation system, the solutions that were obtained often remained unused. It is worth recalling that truncated diffusion processes constitute a main trait of underdevelopment.

The hope is that the renewed and serious attention that people in critical social conditions are receiving coupled with the official commitment to an "Innovative Uruguay" as part of a long term development project will lead to new and higher levels of synergy. In what follows, five potential or actual examples of this synergy are presented.

***Nutrition***

Malnutrition, even if not of the extreme type that can be found in other underdeveloped countries, affects children who, in a high proportion, live in homes under the poverty line. That happens to such an extent that some studies associate the extension of pre-scholar attendance to improvement in children's size because these children only eat satisfactorily at school. Therefore, providing public schools with a simple and cheap "nutrition unit," like a cookie, that can be eaten two times a day and provides all the basic nutrients needed for healthy growth is of paramount importance. A team of biochemists has reached a good solution in the laboratory; from this point onward social policy is needed to organize field trials and lead the way to production.

***Health***

Poor children usually live in neighbourhoods and in houses with bad sanitary infrastructure and with high exposure to contaminated soil. In such conditions an illness associated with intestinal

parasite worms (*Geohelmintiasis*) frequently develops, causing diarrhea, growth difficulties, low levels of attention, and, if not properly treated, even death. However, if early detected, the illness can be cured and further transmission through interpersonal contact can be lowered. A related project was funded in 2003 by a university program aimed at connecting academic research to problems derived from social emergencies. The project was proposed by a joint team of medical doctors and soil specialists to detect the conditions of humidity, temperature, and shade that favoured development of these parasite worms. The team developed a system of early alerts so parents and teachers could put in place special surveillance measures when the probabilities of worm infestations were high.

***Environment***

Uruguay has many polluting industries that cause health consequences for workers and poor people. The impact on the poor relates to the geography of urban poverty: some of the poorest people live near small rivers where industrial pollution accumulates; those who live near garbage dumps are also poor. Some 20 years ago, chemical engineering research groups began to study ways to reverse industrial environmental damage. The main concern then was to reduce chromium levels in the sewage from tanning factories because this was well known to affect the health of tanning workers. After achieving success in this project, the group evolve toward bioremediation. They collaborated with hydraulic engineers and microbiologists to address the water-pollution problems of the textile and meat sectors. The technical approach used in these projects is being adapted to the environmental problems of urban garbage, a significant proportion of which is buried, which increases the danger of underground water contamination in addition to atmospheric pollution. For people living in poverty conditions, and for their many children, the diffusion of these solutions has great potential to improve their quality of life.

***Efficient health system information***

More than 40% of the population in the capital city and more than 60% of the population in the countryside attend different sorts of public health services, including hospitals, the Ministry of Public Health dispensaries, and dispensaries from the Municipalities. Until recently, the clinical histories of patients were scattered between these different health entities, making it necessary to wander from one to another to get all the information needed. This is not only time consuming, but very costly: the cheapest bus ticket is equivalent to the price of one and a half litres of milk. A team of software people undertook a project to unify all the clinical information about public health patients in Montevideo, the capital city. They put this information in computer databases and provided the individual clinical histories to every public health entity in the city. This seems a project without major technical difficulties, which is true when discussing past histories. However, making available new data on clinical histories to all health entities is another story, particularly because the computer network used to relay this information is outdated, slow, and weak. Replacing this network with a modern one was not affordable; the software solution to avoid changing hardware was truly innovative. Perhaps it will be soon possible to extend this strategy to the whole country.

***Affordable hospital equipment***

Uruguay has a long tradition of dialogues between medical doctors and engineers, stemming from pioneering work aimed at measuring and controlling uterus contraction just before birth. As a result, devices were developed to carefully monitor fetus suffering and help lower the rate of child mortality. Two institutional consequences of this tradition have been: the organization of a common chair between the Medicine School and the Engineering School in Biomedical Engineering to train "hybrid" engineers; and the creation of the Biomedical Engineering Group, a formal R&D group devoted mainly to the design of intensive therapy devices. Through both institutional arrangements many prototypes of medical devices have been developed. Once tested, they have usually been incorporated into the intensive care facilities of public hospitals. Some of them were cheaper substitutes for well-known instruments; some were totally new; and some were older designs that incorporated new features to better suit local conditions. All this helps to bridge the sharp divide in access to high-tech medical care between rich and poor.

## 4. Recommendations for the Innovation, Policy, and Science Program

Innovation policies are usually seen as part of economic policies. To enlarge this view to include innovation policies as part also of social policies, new research issues should be fostered. This section will present strategies as well as examples.

### 4.1 Lessons from an Example

We will look at the aims, hypothesis, and results, and make a critical evaluation of a recent Uruguayan university experience, to organize our recommendations for the IPS Program. The program, called "R&D projects to take care of social emergency," was a call for projects to be financed by the University Research Council budget. Its justification noted both the new situation of extreme poverty affecting a high proportion of the population after the crisis of 2002, and the historical commitment of the "Universidad de la República" to the well-being of society as a whole. Both elements required answers from the academic research side, the justification continued, even if it is explicitly recognized that a social emergency cannot be fought only with knowledge and that such an emergency is not mainly the result of a lack of knowledge. Research aimed at finding new knowledge directly connected to social problems can be a tool, among many others, in the national effort to redress social emergency. The university authorities decided to try this innovative path. The phrasing of the call for projects in its operative parts was as follows:

> The research proposals can address, for instance, problems related to habitat, employment, health, education, violence, environment, productive re-activation. The proposals must be research oriented, but they cannot have the format of the classical R&D projects. To be eligible for this new program, the proposals must:
>
> i) identify precisely the problem associated with some expression of the social emergency suffered by the population;
> ii) indicate the shortcomings in terms of the existing knowledge to address possible solutions;
> iii) propose a research strategy for obtaining, even partially, the missing knowledge;
> iv) indicate the necessary conditions to enable the research results obtained to be an effective contribution to the solution of the problem under consideration, indicating as well the actors that should participate in the implementation of the solution;
> v) devise strategies to involve such actors in the discussion of the proposal and to assure their participation in putting into practice the results that can be obtained by the research.
>
> The proposals that this call wants to stimulate need to be, as the former requisites show, intrinsically interdisciplinary. It must be recalled that for effective solutions to be implemented, the missing knowledge alluded in point (ii) is fundamental but not sufficient: in all cases special attention to the conditions allowing the adequate application of the found knowledge will be needed. The organization of working teams, in which diverse perspectives aimed at the searched solution are integrated, will be specially valued.
>
> This program convene all researchers of the Universidad de la República, regardless their area of expertise, to put their capacities to the service of knowledge production with direct application to the solution of current problems of the Uruguayan society related to the social emergency situation.

The results of this call for projects was relatively successful: 50 proposals were presented, covering issues like health, habitat, nutrition, education, alternative productive strategies, the situation of poor women, social disruption, and anti-social behaviour of teenagers. The evaluation process was particularly difficult. The academic part was accomplished without much

problem, leading to the conclusion that most proposals were of good quality. The other part of the evaluation, related to the assessment of the selected problem itself — its importance and incidence in the quality of life of the population — and to the capacity of the proposal to make a sound contribution to solving the problem, were much more complicated and could not be carried out systematically, mainly because of a lack of proper evaluators.[19]

The main hypothesis behind this initiative was that university researchers would be willing to partially shift their research agendas to focus on different objectives if an external actor provided the opportunity and the required funds. In addition, the researchers would gain a feeling of social usefulness. Empirical evidence is too scarce to validate this hypothesis, but the experience supports it. This is a fundamental issue for STI + Social policies.[20]
A secondary hypothesis was that researchers would be able to properly identify problems associated with the social emergency and, at the same time, related these problems to the kinds of knowledge they were able to produce. This hypothesis seems to have been wrong. The impression derived from the proposals is that, generally speaking, the researchers started with their cognitive interests and then looked for problems that could fit into such interests. The selected problems, and the way of addressing them, seem to be biased toward what the researchers were able to do following their traditional ways more than to really rethink their approaches to fit into the cognitive needs of a problem selected primarily by its social relevance.

The lessons derived from this very preliminary experience aimed at blending knowledge production with solving social problems serve as a rationale for the recommendations that follow.

### 4.2 Elements for a program

Four issues seem to constitute the back-bone of a comprehensive program for blending innovation capacities and social demands within the realm of what international donors can reasonably support: (1) demand detection; (2) supply detection; (3) providing linkages; and (4) evaluation and follow-up. Such a program could be seen as a starting point to further develop consistent innovation policies that can also be conceived as social policies, that is, STI + Social policies.

[19] Lack of resources made it possible to support only three projects, completed after 2 years of work. Two of them, related to health and nutrition, respectively, led to a follow-up by non-university organizations: in the case of *Geohelmintiasis*, the capital city Municipality and the Ministry of Health did it; in the case of the evaluation of the nutritional effects of the meals offered at school for children of 9 years and less, it was UNICEF. The third project developed a communication methodology to instil new social identities in a former worker's neighbourhood now heavily hit by unemployment and its social consequences.
[20] Another iniciative, much broader in scope because it was intended at national level involving all researchers in the country was the Venezuelan experience, Agendas Venezuela, organized by the Conicit, the National Council for Science and Technology Research. "The Agendas process was designed as an instrument to connect research, knoweldge, and technology to the needs and opportunities of society. Its methodology should be understood as an interactive public policy based on the coordination of various social agents around common problems, supported by the legitimacy and autonomy of diferent participants interests and oriented towards positive negociation approaches." (Avalos and Rengifo, 2003: 188). A critical appraisal of this initiative is included in the paper.

***Demand detection***

The technological demand stemming from social needs is, in some cases, well known, but a thorough picture of what it looks like in different orders of social life is far from being complete. Of course, the term demand is a tricky one. Who is to decide what people's basic needs are? What should be considered a reasonable coverage of those needs, and so to what extent are they indeed needs?

Both questions are key to legitimate innovation policies integrated into social policies. But even before trying to find some answers, another question appears: is it necessary to have at least a proxy of what the socio-technical demand looks like to devise such policies? The affirmative answer is backed by the former experience: researchers cannot be charged with the double burden of finding the questions and trying to find the answers. They usually do that within their own field of research, but finding the most relevant problems in the realm of poverty, deprivation, and social exclusion is not a task for which they are usually well prepared. Therefore, the detection of social problems for which science, technology, and innovation can provide advancement toward their betterment or solution should not be a task only for the "solving community."

A methodology for the detection of this type of demand at a national or regional level may never have been developed. Besides, more than a one-size-fits-all methodology, different approaches will probably be required for different situations. The technological demand related to social needs in the public sector is fundamental. It includes a high number of sophisticated demands (medical equipment and pharmaceuticals for hospitals, for example), which are a good attractant for innovation efforts. The demand for services that are able to fulfill their function in the midst of a very deprived population is very specific: communications and education, for example, usually fail to provide what is expected because there are not specific enough.

The methodologies for demand detection cannot rely on a single source of information: decision-makers, public purchasing authorities, practitioners in the field, social workers that look to problems from the user perspective, and would-be users themselves, need somehow to be consulted.

Developing and applying these methodologies is one of the pillars that sustain the blending of innovation and social policies.

***Supply detection***

The detection of "who knows what and to do what" is a fundamental question for innovation policies. It is usually posed within a restricted framework related to a given productive sector, a determined technology, or a specific type of actor. For the purpose we are dealing with here, this type of restriction is not possible. Social needs cross all the productive sectors, all technologies and a wide diversity of actors. This is not necessarily an overwhelming difficulty. As we have already noted in the Uruguayan program, researchers are pretty good at relating what they know and what they are able to do with problems stemming from the social sphere, even if these problems may not be the more pressing and many others are not even mentioned. This capacity is a good starting point for supply detection.

There are various levels at which to proceed systematically. One is the level of the individual researcher; another is the level of the research group. Both can be found in universities and in research facilities in the public sphere. They can be reached through specific questionnaires — including a direct question about the potential social use of their expertise. Other important levels to take into account in supply detection include the layer formed by the knowledge-base firms. Associated professionals working as consultants — very common in the agronomic realm in Uruguay and well connected with cooperatives of small rural producers — constitute another example.

In general terms, what is needed is a methodology or methodologies to detect capacities that are potentially able to address social needs. The results should be updated periodically and be easily accessible to diverse users.

***Providing linkages***

There are many ways to foster the encounter between social needs and innovation efforts. One way is to provide a common language in which both the problem and the strategies to pursuit their solutions can be formulated in a meaningful way for all the participants. This implies a sort of translation, which perhaps only truly interdisciplinary teams will be able to address with success. The outcome of this "translation" would be concrete projects that reflect real demands and that are formulated in understandable techno-economic terms.

The diffusion of such projects, even before addressing the issue of how to put them into practice, can be of great use, because it can stimulate the development of new directions of research and of capacity building, both in academia and in the business sector. Once a portfolio of this type of projects is available, classic procedures like competitions for addressing them can be quite efficient.

This is a direct way of fostering linkages. In fact, diffusing information on demand and supply can encourage bottom-up linkage initiatives started by very diverse actors. To enable these initiatives to go beyond the contact stage, it is fundamental to give them support, particularly but not only financial support. This suggests the convenience of having a specialized body, that can be called "the office for technological/social innovation," where such initiatives can be presented, assessed, and "certified" to help them enter into some specific new branch of the financial system.

***Evaluation and follow-up: some indicators***[21]

The propensity of a society to embark on "innovation policies as social policies" can be approximated by some indicators. If effectively embarked on, monitoring the effects of the policies will include follow-up of those indicators, among many others. Two such indicators are briefly mentioned here.

- STI resources dedicated to social urgencies. To our knowledge, this is a seldom used indicator, in spite of being of utmost relevance. It offers information related to the principal justification for STI investment in poor countries. At the same time, it is a fundamental indicator of the long-term strength of STI structures in developing countries, because it is not easy to assume that such countries will invest systematically in STI

[21] This part is essentially taken from Arocena and Sutz (2005).

capabilities if these capabilities are weakly connected with the solution of pressing social problems. Concrete elements related with this indicator can be given, for example, by: (1) absolute and relative numbers of scientists and engineers working in social programs; (2) data about members of the scientific and technological diaspora connected with those programs; and (3) connections of public and private organizations dedicated to the solution of social problems with knowledge-based and high-tech firms.

- Levels of participation of usually neglected knowledge-weak actors in knowledge linkages. If technical change is consistently unfavourable for workers and other less favoured social groups, growth is not socially sustainable, and perhaps not even economically sustainable. Trade unions, cooperatives, NGOs, and other "civil society" associations are not usually considered in STI policies and studies. Information is needed concerning the following questions: Do they have scientific and technical personnel in their staffs? Are they consulted systematically by governments when scientific and technical decisions are adopted? Do they participate in joint tasks with knowledge-generation organizations? Are they entitled to be considered partners in publicly funded projects to foster relations between academy and production? Even partial answers to these questions would be useful for evaluating knowledge linkages.

The systematic study of these indicators could be important to evaluate whether actual innovation processes foster or hamper "social capital" and social cohesion.

## Recapitulation: STI + Social policies against the STI & Inequality gap

Develoment processes should aim at bettering today the quality of life and, at the same time, expanding the capabilities that will allow further progress tomorrow. One way among others to embed STI in development processes is the one presented in this paper. This strategy is specifically oriented to narrowing the gap between expanding STI capabilities at the world level and increasing inequalities – *the STI & Inequality gap*. The strategy is characterized by assigning in STI policies a relevant though by no means exclusive place to social problems, in ways that combine first rate research, effective innovation and *agency*, that is, active participation of people related with such problems. The leading idea is that social policies can act as "incubators" for innovative efforts if the latter help to achieve the aims of the former. If that happens, endogenous scientific and technological capabilities will expand and, at the same time, gain a wider social support and political legitimacy. Consequently, they will we able to make a better contribution to economic development, to human self-sustainable development more generally, and particularly to overcoming pressing needs. This is the target that defines *STI + Social policies*.

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