SCIENCE, TECHNOLOGY AND INNOVATION POLICIES IN LATIN AMERICA: DO THEY WORK?

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SUMMARY

All countries in Latin America and the Caribbean (LAC) have defined and implemented science, technology and innovation (STI) policies with varying degrees of success within three broad economic models, "import substitution", "liberalization and privatization", and later, in some countries, "21st century socialism". While STI policies were being adopted and implemented within the three models, the rate of technological change greatly accelerated and changes in the innovation process occurred, passing from a linear to a non-linear model and further evolving into an "open" model. Such changes induced a growing complexity in the national innovation systems and present new challenges to STI policy making. The adopted policies permitted significant advances, evidenced by existing indicators; however, the LAC region as a whole lags behind other regions. Numerous studies have analyzed this situation and more recently, in the context of an IDRC funded project, the present study surveyed current and former STI leaders for an in-depth analysis of the effectiveness and impact of public STI policies. The responses highlight the achievements and problems that the development of STI faces in LAC. Existing dissatisfaction with the application of the liberalization process and other economic reforms of the 1990's, call for a new development agenda that must include STI to succeed. This requires, in turn, new conditions and rules for governance, in particular policy making, so that STI are stimulated and guided by the search for solutions to existing social and economic challenges considering the growing complexity of innovation systems.

For decades all countries in Latin America and the Caribbean (LAC) have developed governance mechanisms for science, technology and innovation (STI), creating and improving their institutional structures, defining policies and strategies, and executing them with varying degrees of success. In some countries there has been a noticeable improvement, in others the situation remains unchanged and yet in others there is a visible deterioration. As a whole, however, LAC remains behind developed and emerging economies such as China, India and other South East Asian countries. Besides a myriad of national level assessments, there are several regional character in-depth analyses (see IADB, 2001; Albornoz, 2002; OEI, 2004, 2009; OAS, 2004; Velho, 2004; Maloney and Perry, 2006) that explain why this situation occurs. This study examines it as seen from the opinions of STI decision makers and in light of the developments in the innovation process that have taken place in the past few decades.

The first section of this study briefly reviews the techno-economic concepts around which STI evolved in LAC, as well as the changing concepts and practices of innovation. An overview of the situation of STI as measured by current indicators in the presented, followed by a summary of the main results from an opinion survey on the formulation and implementation of STI policies, responded by a selected group of individuals that occupied high directive positions in the national STI organizations throughout LAC. The conclusions emphasize the new perspectives of STI that need to be taken into account for a more effective policy making in LAC.

The Evolution of STI in LAC

Recognizing the importance of state intervention in the promotion of STI as a key input to social

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and economic development, several countries in LAC initiated already in the early 1950's a process for institutionalizing science and technology (S&T) at the government level and defined specific policies. The early debates on S&T took place at a time when the economic theory of "import substitution" was being developed and applied. At the time, the institutional structure and policies adopted in LAC, while theoretically considering applications of S&T to respond to this economic model, actually reflected the more direct interests of the scientific communities, a fact that still continues to have a weight in several countries, but no longer reflects the situation in others.

The decades of the 1960's and 1970's witnessed new approaches to the development of technology. The Andean joint approach exemplifies the new lines of thought in these two decades (Jaramillo and Aguirre-Bastos, 1989). The starting point of this approach was the conception of technology as an essential ingredient of production and, consequently, the policy was defined to regulate technology flows through the control of foreign investment, patents and trademarks; it included instruments addressed to disaggregate the technology package, to adapt, assimilate and create technology, and train human resources. Such policy had a vision of notable coherence in the framework of "import substitution". It founded a techno-economic conception that opposed the view of a development of science with weak linkages to investment, planning and other economic policies.

The Andean policy was directed to strengthen capacities to acquire foreign technology in more favorable conditions. Importing technology while learning, assimilating, stimulating its accumulation, and improving options for its search, was a vital part of a conception that tried to assert a development process based on internal capacities, promoting local production factors and productive knowledge as essential inputs to an independent economic model.

The larger countries of LAC, Brazil, Mexico and Argentina, developed and applied a similar approach and this shared regional vision became the basis for the negotiations of international instruments being discussed during the 70's, 80's and early 90's, such as for example the international code of conduct for the transfer of technology (Aguirre-Bastos, 2001).

All the policies at that time were oriented fundamentally to demand knowledge from an industrialization process and growing markets, which were only achieved partially (Fajnsylber, 1983). The approach supposed the combination of multiple elements, financial, commercial, fiscal, etc., which never appeared in the midst of fragmented and weak institutions and differences between the public and private sectors. Such weaknesses greatly limited the full application of the technology policies during this period.

In spite of their limitations, it is recognized that the instruments applied for the development and transfer of specific technologies both in the Andean countries and others in LAC met with some success. Many productive and social sectors benefited; for example, the forestry, agro-food and mining sectors of the Andean countries or the aircraft and bio-fuels sectors in Brazil. In these cases, capacity building reached important levels and the accumulation of knowledge continued to build up.

Kim (1997) recognizes the importance of the conceptual basis adopted by the Andean countries for the case of Korea. He argues that "during these decades (1960's and 1970's) industrial policy measures which brought about the side of demand technology creating the needs for it, were much more effective in expediting technological learning at the firm level than (global) science and technology policy measures (except for education)".

In the decade of the 1990's it was considered that the "import substitution" model was depleted and, together with the important democratic movement that was taking place in LAC, the liberalization of the economy became a paradigm for development. It was presented as providing a way out of inefficient strategies associated with trade protection and high levels of government intervention, and as a means for fully exploiting the opportunities generated by globalization. This view represented a significant break from the vision that underlaid development strategies for several decades, that "late industrialization" required a significant degree of government intervention to succeed (Ocampo, 2001).

Some countries in LAC, such as Brazil and Chile, together with other emergent economies such as China and India, successfully opened their economies at varying degrees through different routes, providing an illustration of gradualism and pragmatism in redefining past policies and suggesting that under the broad heading of deregulation, privatization and market liberalization, there can be different approaches to opening up, depending on the country's particular circumstances (UNCTAD, 2003).

In other countries, where liberalization policies were adopted with great enthusiasm, the opening could neither produce faster growth nor social advances, and rather deepened dependence and inequality. Under such context, a small group of countries searched for new economic policies, one of which is that adopted since the early 2000's denominated "21st Century Socialism", a nationalist-populist model strongly based on the belief that the existing capacities in social movements, together with full state intervention, can produce important results in the fight against poverty and other social illnesses. The model is still to be proven as a real and good alternative to the ineffective liberalization model.

In the 1990's many of the countries of LAC following the liberalization drive, withdrew STI from the already secondary role they played in the political agenda, further marginalizing S&T institutions and STI policies. In this group of countries, the impetus of the earlier years was lost as was the knowledge accumulation process that had slowly been taking place, the societal support continued to be weak, and at the same time the privatization and capitalization processes that occurred did not necessarily become the best channels for the transfer and diffusion of technology in the national economies.

Another smaller set of countries, on the other hand, adopted measures to advance STI, strengthening their innovation and other related systems, such as higher education, thus producing a separation between laggards and forward looking countries, with consequences that can now be perceived by existing indicators. These latter set of countries recognized the significant change that was taking place due to the development of new technologies and the changing characteristics of innovation and the national innovation systems as discussed in continuation.

The first gene ration of innovation processes "technology push" which appeared in the 50' and 60's, was dominated by the idea that innova-

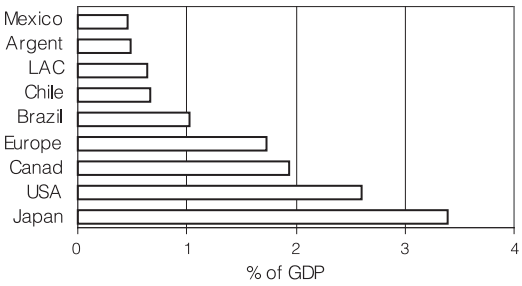

Figure 1. Investments in R&D in 2006 as % of GDP. Source: OEI (2009).

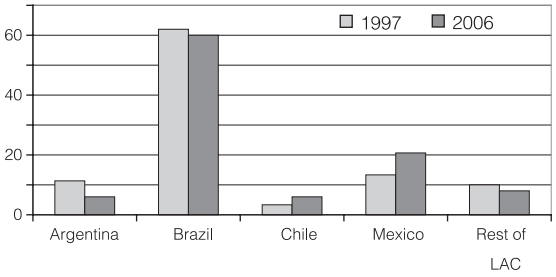

Figure 2. Percentage change in investment patterns in selected countries. Source: OEI (2009).

tions are created directly from basic research to R&D in enterprises, to the production line and by the use of marketing instruments directed to the client. This model was replaced by a second generation model of "market demand", as the saturation of markets called for a greater individualization and diversification of products, and more attention was paid to market demands and customer needs. This model was dominant until the 1970's.

The market dynamics and the increase of technological change called for a third generation of innovation process model, denominated the "coupled model" that reduced the so called "time to market". In this model, feedback loops between the different phases of the innovation process were introduced yielding a situation where for the first time the linearity in the innovation processes was questioned. While the model took care of feedback loops between neighboring process phases, it was considered that information flows were not only fruitful between actors of such phases but also between actors of all phases in the process, and a fourth generation of innovation models, called the "concurrent engineering model" appeared and dominated until the mid-1990's.

It then became clear that innovations were not only the result of a process occurring in the firm, but the result of interactive knowledge exchange processes between enterprises, universities, research organizations and other agents all of which contribute to the development of new technological knowledge. Further, it also became clear that innovation was not only technology-based, as innovations in organization and other social processes were just as important. As a result, a fifth generation of innovation model called the "systems integration and networking" was born, leading to what is now known as "open innovation" (Chesbrough, 2003).

In this process, national innovation systems become more complex due to four types of continuous differentiations (Aguirre-Bastos and Fröhlich, 2009): a) increasing specialization of different actors; b) specialization at the institutional level, particularly in enterprises, and the existence of new rules of governance or the increasing importance of particular organizations from other functional systems of society, such as education; c) the uneven sector development occurring in most economies, that precludes a homogeneous system and renders it difficult to define a single national system by the simple aggregation of sectors or regional innovation systems; and d) differentiation referred to space, as organizations at the local level cooperate in innovation processes with organizations from the regional, national or global level.

The Situation of STI in LAC

The investment made by LAC in R&D as a percentage of GDP is presented in Figures 1 and 2, which show that there has been no major change in pattern during the past decade. Only Brazil has reached over 1% of GDP, Argentina has seen a drop from 1997 and Chile and Mexico have experienced a larger growth during the same period. It is also evident that investment is still dominated by the public sector (>70%). The regional average is as small as 0.63% compared to the European average of 1.73% or Asia 2.28%.

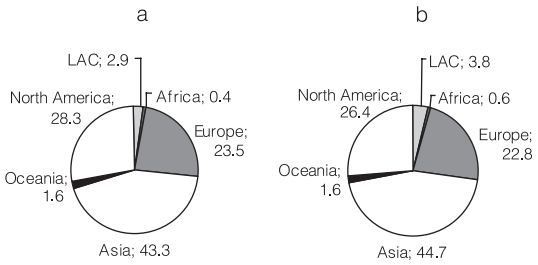

Figure 3. World distribution of the number (%) of researchers in 1997 (a) and 2006 (b). Source: OEI (2009).

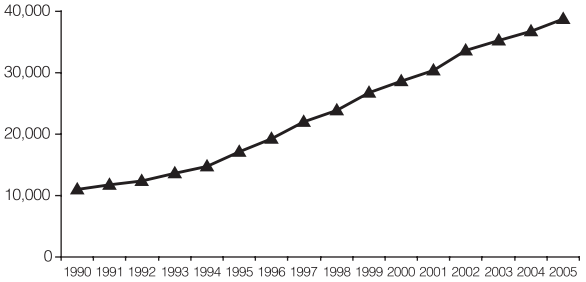

Figure 4: Number of LAC publications in the SCI. Source: (OEI, 2009).

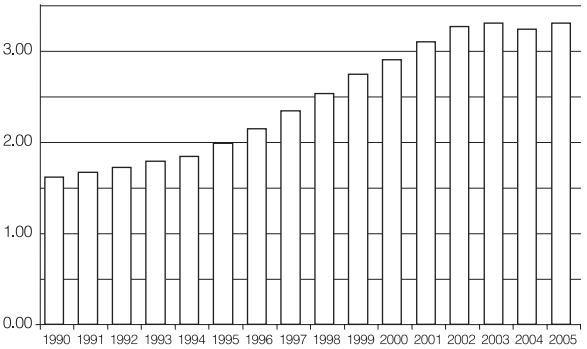

Figure 5. Percentage of articles from LAC with respect to the world total. Source: OEI (2009).

The number of researchers in LAC has grown from around 115000 in the early 90's to around 170000 in 2006. Although this constitutes an important growth rate, the number of researchers is still small compared with other regions of the world. Figures 3a and b show the world distribution of researchers in 1997 and 2006, respectively.

Even though the contribution of LAC as a fraction of the world scientific output to mainstream of knowledge is still small (3%), the quality and volume of science has improved in all fields. The presence of LAC in the SCI has doubled in the past decade, having reached a larger growth rate when compared with other regions of the world (Figures 4 and 5), but the differences within LAC countries are overwhelming (Figure 6).

The more recent progress in the access, use and analysis of information on scientific publications and patents has opened an innovative way to study the structure and evolution of science. The work of Igami and Saka (2007) clearly shows the multidisciplinary character of different scientific fields and also shows how science evolves not only through disciplines, but also countries and regions. In their analysis of 7218 cited papers, which were grouped in 14 categories, it is recognized that publications from Brazil and Mexico can be found in all categories, pointing out that these countries, together with China, India and Russia, are becoming important participants in knowledge networks and are becoming important players in the world's more diversified and complex environment of STI.

In spite of the increase in the volume and quality of research, the number of locally generated patents continues to be small and slowly growing throughout the decade, while the number of foreign patents continues to be large, as shown in Figure 7.

In the above context and in spite of the observed advances, LAC as a whole still lags behind other regions in productivity and competitiveness and its social indicators show a dramatic situation characterized by poverty conditions, inequality and many unmet basic needs. This situation is far from optimal when compared to other developed or developing countries, such as China, India and other smaller South East Asian countries.

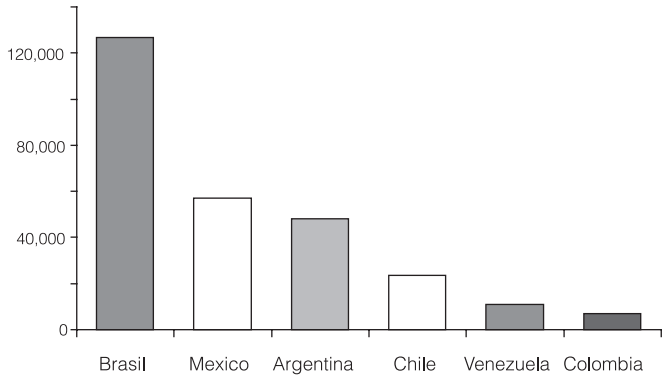

Figure 6: Total number of publications in selected countries (1994-2005). Source: OEI (2009).

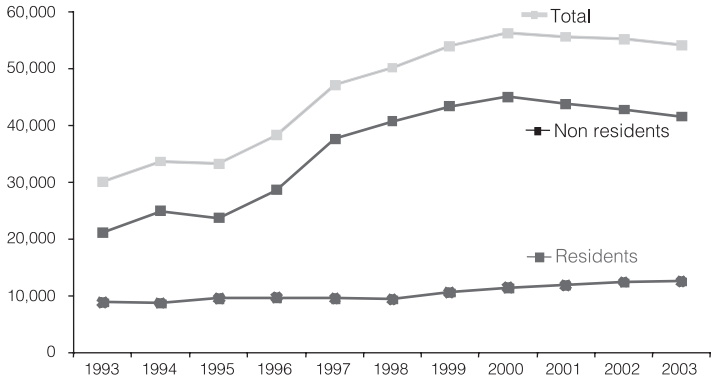

Figure 7: Patent applications in LAC. Source: OEI (2009).

Why is the Situation as it Is?

Methodology for the identification of achievements and limitations

In order to identify reasons for the achievements and limitations in the definition and implementation of STI policies, this study approached 102 STI current and former leaders in LAC to inquire their opinion. A structured questionnaire was prepared and some on-site personal interviews were conducted. Table I provides the list of the countries where the surveys were sent and the number of responses received. A literature search was also conducted for analyzing existing policies.

Of the leaders approached, 88 were males (of which 31 responded) and 14 females (of which 2 responded). Of the respondents, 18 occupied the position of Minister of State or head of the national S&T agency, and 15 held upper level directive positions, or were high level university authorities or chief executive officers in the private sector.

TABLE I
LIST OF COUNTRIES WHERE QUESTIONNAIRES WERE SENT AND NUMBER OF RESPONSES RECEIVED

Country	Surveys sent	Responses received
Argentina	13	4
Bolivia	7	5
Brazil	8	1
Chile	7	2
Colombia	5	3
Costa Rica	5	3
Cuba	3	0
Dominican Rep	2	0
Ecuador	5	2
El Salvador	2	2
Guatemala	3	1
Honduras	1	0
México	5	2
Nicaragua	3	0
Panama	3	1
Paraguay	1	0
Peru	6	4
Uruguay	4	0
Venezuela	11	3

Achievements and critical problems

The response to the survey highlighted the many different problems that the development of STI face in LAC as well as the results obtained by the application of adopted policies. It is of course impossible to generalize the situation as it varies largely from country to country, but there are common trends that can be identified, as well as interesting examples of success stories that can serve as benchmarks.

For many of the governments of LAC, STI was not and is not a priority; it is simply not considered a key driver of change. The lack of political will, even when policies have been formulated, is mentioned as the most common cause for the slow development of S&T in most countries. When this will existed, it was readily translated into important advances illustrating that, at least in some areas, there is a critical mass that, if properly used, can produce results with impact. All respondents except one was in favor of a full private-led growth, and concluded that the state plays a key role in the development of STI, and the private sector should be seriously engaged.

Policies were adopted under different forms and the more recent ones have as their goals to "create and build-up the national science, technology and innovation system", or the "national innovation system" or the "science and technology system". In many cases, the denomination of "system" is only formal, as the policies do not necessarily follow a systemic approach.

In spite of the fact that all respondents indicated that policies were only partially executed, several positive impacts are identified. In the case of Brazil, for example, it is felt that their implementation contributed to the strengthening of the scientific and technological communities; their application and the successful results that

were obtained permitted to take S&T to the enterprises as well as to create further confidence in the local R&D capacities in particular areas of production. Some plans, for example, of Brazil, Colombia and Costa Rica, were successful in the implementation of activities that integrated the public and private sectors by establishing "common agendas" in priority areas. The adopted policies and plans permitted in general to generate new spaces for the development of S&T, to earmark special budgets, to build new infrastructure and to train human resources. Policies also had the merit of bringing together many institutions that worked in isolation and which could make an important impact on the operation of the national system.

Together with these opinions, there is also a strong feeling among respondents that policies had little influence on the social and economic development of the countries. There are several reasons for this to occur that have been pointed out. Most plans are self-centered in the same S&T system that generates them, constructed by a closed community (mainly academic) for itself; the participation of the private productive sector in the definition of plans has been very limited; and there is still a supple side vision in the plans and an implicit lineal model of STI, although in some policies (such as those of Mexico) a demand driven portfolio of R&D projects can be found. Further, the later generations of innovation process as discussed above have been absent from consideration in most policies in LAC.

The partial application of policies and in some cases their limited impact is also due to the lack of continuity. Many respondents proposed that continuity should be a "state policy". Its absence only results in budget cuts, task duplication, personnel change, and changes in orientation. Under such context of permanent change, country efforts to analyze, plan and establish certain goals to improve indicators, are simply wasted.

One issue that is frequently mentioned by respondents is that policies should be more realistic, more detailed and flexible. One of the characteristics of the policies in the past has been the extensive list of goals, programs and projects to be executed in short periods of time, far beyond the country's capacities, and rare search for niches where the countries have installed competitive capacities.

While extensive, many policies and the strategies derived from them lack the necessary depth to induce interest in the productive sector, as they are stated vaguely and lack clear goals and indicators to measure their accomplishment. In other cases, ideology predominates over pragmatism and also fails to identify best practices. Benchmarking is deemed necessary in most cases. Some respondents indicate that it would be necessary to give priority to linkages with global markets before investing time and resources, and plans should not include matters out of competitive advantages at the international level.

Further, the non-applicability of policies according to respondents is due to what could be called "faulty legislation" or non-compliance. In Colombia, for example, COLCIENCIAS did not centralize the research budget of public institutions as established by law, because of opposition and other bottlenecks in the public sector itself. Another case is that of Peru, where CONCYTEC operates under the aegis of the Ministry of Education; while the law states that it should be under the Presidency of the Council of Ministers.

When dealing with national STI policies and plans it is impossible not to mention the role of universities and particularly public universities, which are responsible for a large fraction (generally >70% of R&D). This is an issue raised by some respondents who believe that in many countries, universities lack research development policies addressed to links with the productive sectors. In the absence of policies, universities do not attract young people to technical or scientific careers, and incentives such as protecting the careers of researchers, granting of fellowships and support for travel to international and national conferences, etc. are lacking. Without internal policies in the universities, national policies calling for the development of STI can only have a very limited impact.

All respondents agree that education and training of a workforce for S&T is essential for success. Some indicated that education should be completely revamped from the first grade of primary school up to the university, and more particularly at the doctoral level. Recognizing this need, several countries such as Brazil, Mexico, Argentina, Colombia and Venezuela created postgraduate courses of importance while at the same time establishing programs allowing nationals to study abroad under government fellowships. A pioneering effort along this line was the "Mariscal Sucre" program in Venezuela, in the 1960's and 1970's, that permitted a large contingent of young graduates to obtain their degrees in more developed countries, but many of them could not find adequate conditions for research upon returning, a fact that diminished the value of such a pioneering project.

In LAC there exists a critical mass of researchers and S&T managers only in a reduced number of institutions and enterprises. Several respondents find an extreme need to train more human resources for the operation of the national S&T agencies and management of technology for industry, and it is felt that there is a great need to have qualified researchers in the industrial sectors.

A particularly difficult problem to be solved in many of the smaller countries, for which until now no solution has been found, is that young Ph.D.s upon return do not find a workplace in the universities or have to go back to junior positions they held in the past, when they left. The lack of incentives that should be provided by universities is either forcing young Ph.D.s to remain abroad or simply younger professionals to abandon the idea of pursuing a higher degree. This situation suggests that new scientists and engineers are only functional to the competences of the global market, but not necessarily that of the developing countries. This fact, the political persecution that occurred mainly in the 70's and 80's in some countries, and a still unfavorable working environment in many countries is a cause of an extensive brain-drain that affects LAC progress in science and technology.

In spite of the fact that extensive training took place to build up a solid base of human resources in the management of S&T institutions, some respondents consider that there is still much to be done in this area to reach a critical mass in their countries. Many national agencies were forced in the past to appoint non specialized personnel to key posts, a problem further aggravated by the high rotation of personnel. There is a great need for appropriate, trained, personnel to manage S&T organization as well as their permanence.

Policy instruments such as foresight have been used in a limited way. The largest effort was that of Brazil, which created a specific agency for this purpose and conducted several

studies, as for example one addressed to specific industrial sectors by the Ministry of Development and a second on the S&T system conducted by the Ministry of Science and Technology. The first effort received the support of UNIDO, which at the same time contributed to similar studies in Uruguay, Mexico and Venezuela. Using other participatory approaches, several countries have adopted long-term policies, such as Colombia (2005-2014) and Peru (2006-2021).

Financial mechanisms are powerful policy instruments and have made important contributions to advance STI when they have operated well. There are many examples, such as those of Chile and Costa Rica, and sectorial funds in Brazil and Mexico have also been quite successful in developing R&D capacities. In general however, it is felt that LAC lacks effective financial systems-mechanisms for technology and innovation.

The lack of financial resources is identified as a serious bottleneck for the development of STI in LAC. If these activities are to have any impact, larger investments are absolutely necessary. The goal of reaching at least 1% of GNP must be met. In the opinion of several respondents what is needed are more competitive funds, the definition of new financial mechanisms for research and the promotion of private sector investment.

On the other hand, small grant programs have allowed laboratory and information purchases, participation of researchers in meetings of different kinds, abroad and within the country, organization of scientific fairs, etc. The impact of these small grant programs still needs to be measured, but certainly they constituted an invaluable input for many research groups, especially in the smaller countries of LAC.

Other problems identified together with insufficient funds include enormous year to year variations in budgets, which makes planning difficult; further, agencies managing funds do not have sufficient autonomy and cannot become more agile to respond to R&D needs. Bureaucratic impediments are recognized as having a very negative impact in the execution of national policies and plans.

Together with the needed flexibility in the operation of funds, many respondents have signaled that the decentralization of the management of STI is absolutely necessary if it is to grow and have larger impacts. Some countries, such as Mexico and Colombia, have made efforts along this line. In Mexico, there was a growing support to research projects in different centers and universities of the country; particularly the National Council for Science and Technology promoted the creation of research centers outside the capital city.

Linkage between research-production-government has been a matter of discussion for decades in LAC, and policies have introduced basic guidelines for it to occur. As a result there are slow advances in their establishment, such as contracts for university services and research by industry and the use of locally installed capacities for infrastructure projects, providing positive signals in the increasing credibility of researchers by private sector entrepreneurs. Many respondents believe that the process of implementation of linkage policies is a relatively recent phenomenon in most countries and that it will take some time to measure a real impact.

For the better development of links, the S&T agencies established alliances for joint investments in R&D with other government organizations. This has been a way to break the self-centered vision that had plagued S&T organizations for many years and, in this way, links between research organizations, enterprises and government were created and operated. In spite of evident successes in this process, many respondents feel that there is still a long way to go to create a strong credibility of researchers in front of entrepreneurs.

A lesson from the experience of the past years is that having laws, policies and plans is not enough to advance STI. It is necessary to mobilize the civil society, and for that a culture for research and innovation needs to be created. Respondents indicate that advances have been made in the creation of a public conscience around S&T, but these must be deepened, citizens must appreciate the benefits of S&T and a public conscience around these benefits (and risks) must be created. For this to happen, an informed public is fundamental and policy must contemplate ways to democratize itself by facilitating an ample participation of stakeholders and citizens in the decision-making processes.

The internationalization of science is mentioned in the survey as an important policy achievement, but at the same time respondents state that it is necessary to further promote international strategic alliances and increase interagency cooperation to benefit from their programs. Cooperation among LAC countries has been promoted for years by regional institutions that have allowed the execution of joint projects and laboratories, co-publications, and a few innovation projects. Many key players in cooperation and networking were recognized in the survey, among them CYTED, the Organization of American States, INTERCIENCIA Association, the Andres Bello Agreement, the Organization of Ibero-American States, IDRC and others, which contributed strongly to improve networking in LAC.

Several responses highlighted that networking among scientific institutions was also an important achievement in the application of policies. Although there is certainly much space to improve networking, it is true that after many years of efforts the region has become conscious of this need.

The value in the use of developing country nationals living abroad has recently been discussed, as part of a broader comparative study, by Dalhman (2008) for the case of Brazil, China and India, showing the extensive and successful use that the two later countries have made of this community, using different channels. In the case of LAC, Colombia through the Caldas network has advanced in this front with success, but a more formal evaluation is still to be made. Other support networks have also been organized by scientists themselves.

An overall view of the situation of the national STI systems (or national innovation systems) in LAC show important weaknesses that are reflected from the responses of the surveyed authorities:

-- Rigidities in organizations characterized by obsolete or inappropriate institutions. A resistance to change stems from different reasons but a fundamental one is a knowledge and "innovation culture" gap in the leadership. Particularly weak are firms that do not value creativity and innovation, and undervalue human capital.

-- Valuable but still limited number of networks and thus knowledge and information flows.

-- Path-dependent system failure characterized by the tendency of organizations to be path dependent.

-- Organizational inefficiency resulting from history and adherence to previous environments and a strong feeling that innovation brings uncertainty.

-- Organizational ineffectiveness as measured by the amount of relevant research and training institutions and their links to production and more particularly the dominant SME sector. Many coordinating and policy bodies themselves lack broad and specific competences, particularly in the smaller countries

-- Institutional gaps that manifest themselves as lack of rules of the game, poor enforcement of contractual laws, and inadequate intellectual property laws, and other norms that constitute disincentives to innovation and learning.

An overall look at the existing policies and opinions of respondents to the survey, show that these must:

-- Shift from a reactive to a proactive view.

-- Be guided by a set of principles such as universality, efficiency, etc.

-- Be able to adapt to changes, specially the rapidly evolving technological change.

-- Search for excellence in research and action plans identified within a strategic vision.

-- Induce private participation and investment in S&T and particularly R&D.

-- Establish and introduce benchmarks.

-- Induce changes in other policies, such as for example industrial or agriculture, that will strengthen the sectors with a greater technological intensity and higher added value.

-- Give priority to national problems in research, not from the view of a scientific discipline, but guaranteeing freedom of research, especially in the university environments.

Conclusions

Although the STI leaders surveyed in this study were incharge of the definition and execution of policies in their respective countries, their responses provide a clear vision of the difficulties they themselves faced while executing their responsibilities. One reason for this is that such leaders were brought by governments to occupy high positions considering their successful careers in science or technology, so they would project a positive image towards society, but in practice lacked the necessary political backing from their patrons.

From the review of opinions of the leaders surveyed in this study, it seems important to face at least two basic challenges confronting LAC: to conduct world-class scientific research and to create innovative capacities. The co-evolution of S&T and innovation has been discussed by Dutrenit *et al*. (2008), who in the context of the knowledge economy consider that this is crucial for developing countries.

For both basic challenges to be met, it is necessary to continue defining effective public policies. Following the debate in economics, around the question of which STI policy interventions should be legitimized, two arguments can be put forward. The first is that, in the neoclassic theory, interventions are only legitimized by market failure, and in the case of STI such failure is given in basic research; thus, policy is obliged to fund basic research in universities as well as in non-university-research-organizations. The second argument is that in evolutionary economics, system failure also legitimizes STI policy intervention. Here, four deficits which legitimize STI interventions are to be found: a) deficit in the interaction between actors; b) deficit in linking innovation systems among themselves; c) deficit in linking the innovation systems to other systems in society; d) deficit in the observation of changes in the system's environment (Aguirre-Bastos and Fröhlich, 2009).

The debate in LAC should then center on the extent that intervention should take, regarding how governments can interact more efficiently with academia, industry and services, financial sectors and other key economic and social actors for the advancement of STI.

The growing and already existing dissatisfaction with the application of the liberalization process and other reforms of the 1990's, calls for a new development agenda that must include STI to be successful. Such situation calls on politicians and decision makers to structure new conditions and rules for governance of STI, in a way that research and innovation are stimulated and guided by the search for solutions to challenges. These new conditions must consider the existence of a system of innovation that contains all the characteristics of complexity, self-organization, emergence and non-linearity, and that policy measures should be seen as interventions in such systems as the traditional forms of decision and legitimation are more and more obsolete.

Due to the impossibility to forecast complex innovation systems, adaptive and reflexive governance principles are needed. In addition, platforms and other "weak" coordination regimes might be more efficient to govern the system than traditional governance rules. They can serve as a backbone for participatory processes in the initiation and steering of collective innovation strategies.

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POLÍTICAS DE CIENCIA, TECNOLOGÍA E INOVACIÓN EN AMÉRICA LATINA: ¿FUNCIONAN?

Carlos Aguirre-Bastos y Mahabir P. Gupta

RESUMEN

Todos los países de América Latina y el Caribe (ALC) han definido e implementado políticas de ciencia, tecnología e innovación (CTI) con diferentes grados de éxito y dentro de tres modelos económicos, "substitución de importaciones", "liberalización y privatización", y mas recientemente en algunos países "socialismo del siglo XXI". Mientras que las políticas de CTI estaban siendo adoptadas e implementadas dentro de tales modelos, la tasa de cambio tecnológico aceleró grandemente y ocurrieron cambios en el proceso de innovación, pasando de un modelo lineal a uno no lineal y evolucionando hacia un modelo "abierto". Tales cambios indujeron una creciente complejidad en los sistemas nacionales de innovación y presentan nuevos desafíos a la elaboración de políticas de CTI. Las políticas adoptadas permitieron avances significativos, evidenciados por indicadores existentes; sin embargo, la región de ALC como un todo esta atrás de otras regiones. Numerosos estudios han analizado esta situación, y más recientemente, en el contexto de un proyecto auspiciado por el IDRC, el presente estudio llevó a cabo una encuesta entre antiguos y presentes líderes de CTI, para realizar un análisis en profundidad sobre la efectividad e impacto de las políticas publicas de CTI. Las respuestas muestran los logros y los problemas que el desarrollo de la CTI enfrenta en ALC. La insatisfaccion existente con la aplicación del proceso de liberalización y otras reformas económicas de los 1990's convocan a una nueva agenda del desarrollo, que debe incluir la CTI para ser exitosa. Esto requiere, a su vez, nuevas condiciones y reglas de gobernabilidad, en particular la definición de políticas, de tal manera que la CTI sea estimulada y guiada por la búsqueda de soluciones a los desafíos sociales y económicos existentes, considerando la creciente complejidad de los sistemas de innovación.

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RESUMO

Todos os países da América Latina e o Caribe (ALC) tem definido e implementado políticas de ciência, tecnologia e inovação (CTI) com diferentes graus de êxito e dentro de três modelos econômicos, "substituição de importações", "liberalização e privatização", e mais recentemente em alguns países "socialismo do século XXI". Enquanto que as políticas de CTI estavam sendo adotadas e implementadas dentro de tais modelos, a taxa de câmbio tecnológico acelerou grandemente e ocorreram mudanças no processo de inovação, passando de um modelo linear a um não linear e evolucionando para um modelo "aberto". Tais mudanças induziram uma crescente complexidade nos sistemas nacionais de inovação e apresentam novos desafios à elaboração de políticas de CTI. As políticas adotadas permitiram avanços significativos, evidenciados por indicadores existentes; entretanto, a região de ALC como um todo esta atrás de outras regiões. Numerosos estudos têm analisado esta situação, e mais recentemente, no contexto de um projeto auspiciado pelo IDRC, o presente estudo realizou uma pesquisa entre antigos e presentes líderes de CTI, para realizar uma análise em profundidade sobre a efetividade e impacto das políticas públicas de CTI. As respostas mostram as conquistas e os problemas que o desenvolvimento da CTI enfrenta em ALC. A insatisfação existente com a aplicação do processo de liberalização e outras reformas econômicas dos 1990's convocam a uma nova agenda de desenvolvimento, que deve incluir a CTI para ser exitosa. Isto requer, por sua vez, novas condições e regras de governabilidade, em particular a definição de políticas, de tal maneira que a CTI seja estimulada e guiada pela busca de soluções aos desafíos sociais e econômicos existentes, considerando a crescente complexidade dos sistemas de inovação.