Gustavo Crespi · Gabriela Dutrénit
Editors

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The Latin American Experience

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Contents

Acronyms

ANII	Agency for Research and Innovation, Uruguay
ANPCYT	National Agency of Scientific and Technological Promotion, Argentina
ASI	Salvadoran Industrial Association
BCR	Central Reserve Bank, Peru
BDESAL	Development Bank of El Salvador
BFA	Bank for Agricultural Promotion, El Salvador
BH	Mortgage Bank, El Salvador
BNDES	Brazilian Development Bank
BoP	Base of the Pyramid
CAF	Latin American Development Bank
CDB	China Development Bank
CENTA	National Center of Agricultural and Forestry Technology, El Salvador
CIATEC	Center for Applied Innovation in Competitive Technologies, Mexico
CIATEQ	Research and Technical Assistance Center of the State of Querétaro, Mexico
CICIC	Impulse and Coordination Commission for Scientific Research, Mexico
CIES	Ecologic Research Center of the Southeast, Mexico
CIESAS	Center for Research and Higher Studies in Social Anthropology, Mexico
CIM	Metrology Research Center, El Salvador
CINDE	Costa Rican Investment Promotion Agency
CIQA	Applied Chemistry Research Center, Mexico
CITEs	Technological Innovation Centers, Peru
CNC	National Quality Council, El Salvador
CNEA	National Atomic Energy Commission, Argentina
CNIC	National Innovation Council for Competitiveness, Chile
CNR	National Registry Center, El Salvador
COMEX	Costa Rican Ministry of Trade
CONACYT	National Council for Science and Technology, Mexico

CONADECYT	National Council of Scientific and Technological Development, Bolivia
CONADEI	National Commission for Export and Investment Promotion, El Salvador
CONAE	National Space Activities Commission, Argentina
CONAMYPE	National Commission for Micro and Small Enterprises, El Salvador
CONCYTEC	National Council for Science, Technology and Innovation, Peru
CONESIC	National Council of Higher Education and Scientific Research, Mexico
CONI	National Council of Research, Peru
CONICIT	National Council for Scientific and Technological Research, Costa Rica
CONICYT	National Commission for Scientific and Technological Research, Chile
CONICYT	National Council of Innovation, Science and Technology, Uruguay
CORFO	Chilean Economic Development Agency
CORSAIN	Salvadorian Corporation of Investments
CPR	Costa Rica Provee
DCE	Domestic Component of Exports
DCYT	Directorate of Science and Technology, Bolivia
DFID	UK Department for International Development
DIDT	Direction of Quality and Production and of Technological Innovation and Development, El Salvador
DIGESTYC	General Directorate of Statistics and Census, El Salvador
DNP	National Department of Planning, Colombia
EAP	Economically Active Population
ECLAC	Economic Commission for Latin America and the Caribbean
EMBRAPA	Agricultural Research Corporation, Brazil
ENI	The National Innovation Strategy, Chile
EPZ	Export Processing Zones
ESC	Economic Service Centres
FCCyT	Scientific and Technological Advisory Forum, Mexico
FDE	Economic Development Fund
FDI	Foreign Direct Investment
FEDISAL	Foundation for Comprehensive Salvadoran Education
FEPADE	Entrepreneurial Foundation for Educational Development, El Salvador
FIA	Agrarian Innovation Fund, Chile
FIDETEC	Technological Modernization Fund, Mexico
FIES	Higher Education Research Fund, El Salvador
FINCYT	Fund for Innovation, Science and Technology, Peru
FINNOVA	Sectorial Fund for Innovation, Mexico
FOEX	Direction of Export Promotion, El Salvador

FOMILENIO	Millennium Fund, El Salvador
FONCYT	Fund for Scientific and Technological Research, Argentina
FONDECYT	National Fund for Scientific and Technological Research and Technological Innovation, Chile
FONDEPRO	Production Development Fund, El Salvador
FORCCYTEC	Fund for Strengthening Science and Technology Capabilities, El Salvador
FORDECyT	Fund for the Regional Fostering of Science, Technology and Innovation, Mexico
FSG	Salvadoran Guarantee Fund
FUSADES	Salvadoran Foundation for Economic and Social Development
GACTEC	Science and Technology Cabinet, Argentina
GATT	General Agreement on Trade and Tariffs
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditure on Research and Development
GMI	Ministerial Cabinet for Innovation, Uruguay
GVC	Global Value Chains
IBRD	International Bank for Reconstruction and Development (World Bank)
IBTA	Bolivian Institute of Agricultural Technology
ICE	Costa Rican Electrical Institute
ICT	Information and Communication Technologies
IDB	Inter-American Development Bank
ILPES	Latin American and Caribbean Institute for Economic and Social Planning
IMSS	Mexican Institute of Social Security
INA	National Technical Institute, Costa Rica
INAOE	National Institute of Astrophysics, Optics and Electronics, Mexico
INCAGRO	Innovation and Competitiveness Program for Peruvian Agriculture
INECOL	Ecology Institute, Mexico
INIA	National Institute for Agricultural Research, Peru
INIC	National Institute of Scientific Research, Mexico
INIFAP	National Institute for Forestry, Agriculture and Farming Research, Mexico
INTA	National Institute for Agricultural Technology, Argentina
INTEC	Technological Institute, Chile
INTI	National Institute of Industrial Technology, Argentina
IPN	National Polytechnic Institute, Mexico
ITINTEC	Institute for Industrial Technology and Technical Norms, Peru
LAC	Latin American and the Caribbean
LANFI	National Laboratory for Industrial Development, Mexico
LDCyT	Law on Scientific and Technological Development, Mexico
LEO	Official Statistics Law, El Salvador

LIPS	Local Innovation and Production Systems, Brazil
MAG	Ministry of Agriculture and Farming, El Salvador
MCC	Millennium Challenge Corporation, El Salvador
MEC	Ministry of Education and Culture, Uruguay
MEF	Ministry of Economics, Uruguay
MGAP	Ministry of Agriculture, Uruguay
MICIT	Ministry of Science and Technology, Costa Rica
MIEM	Ministry of Industry, Uruguay
MINCyT	Ministry of Science and Technology, Argentina
MINCyT	Ministry for Science, Technology and Productive Innovation, Chile
MINEC	Ministry of the Economy, El Salvador
MINED	Ministry of Education, El Salvador
MNE	Multi-national Enterprise
MSP	Public Health Ministry, Uruguay
MTSS	Costa Rican Ministry of Labor
NAFTA	North American Free Trade Agreement
NIS	National Innovation System
OPP	Budget and Planning Office, Uruguay
OSA	Salvadoran Accreditation Organism
OSARTEC	Salvadoran Technical Regulation Organism
OSN	Salvadoran Regulatory Organism
PAC	Brazilian Infrastructure Plan for the Acceleration of Growth
PAE	Strategic Areas Program, Argentina
PRA	Poverty Reduction and Alleviation Project, Peru
PCCI	Presidential Council for Competitiveness and Innovation, Costa Rica
PDIT	Technological Development and Innovation Program, Chile
PDP	Productive Development Policies, Costa Rica
PECYT	Special Program for Science and Technology, Mexico
PENCTI	Strategic National Plan for Science, Technology and Innovation, Uruguay
PFCT	Doctors Training Projects in High Priority Technology Areas, Argentina
PICT	Science and Technology Research Projects, Argentina
PICTO	Guided Science and Technology Research Projects, Argentina
PID	Research and Development Projects, Argentina
PIDRI	Research and Development Projects for Researcher Relocation
PIEBT	Incubator Program for Firms based on Technology, Mexico
PME	Equipment Modernization Projects, Argentina
PMT	Technological Modernization Program, Argentina
PNCTI	National Plan for Science, Technology and Innovation for Competitiveness and Human Development, Peru
PND	National Development Plan, Mexico

PNICT	National Innovation, Science and Technology Policy, El Salvador
PRAMIN	Adaptation and/or Infrastructure Improvement Projects, Argentina
PREAEM	Special Program for Promoting Academia-Firm Linkages, Mexico
PRH	Human Resources Program, Argentina
PROCOMER	Costa Rican Foreign Trade Corporation
PROMTEC	Program for the Fostering of Technological Modernization in Industry, Mexico
R&D	Research and Development
R&D&I	Research, Development and Innovation
REDNACECYT	National Network of Science and Technology State Councils, Mexico
ROA	Return on Average Assets
ROE	Return on Average Equity
S&T	Science and Technology
SBA	Small Business Administration
SCM	Subventions and Compensatory Measures
SDC	Swiss Development Cooperation
SECyT	Secretary of State for Science, Technology and Productive Innovation, Argentina
SEN	National Statistics System, El Salvador
SEP	Public Education Ministry, Mexico
SHCP	Ministry of Finance and Public Credit, Mexico
SIGET	General Superintendence for Electricity and Telecommunications, Mexico
SNI	Chilean National Innovation System
SINACTI	National System of Science, Technology and Innovation, Mexico
SINACYT	National System of Science, Technology and Innovation, Peru
SINALIT	National System of Alliances for Technological Innovation, El Salvador
SME	Small and Medium Enterprise
SNCT	National System of Science and Technology, Bolivia
SNCTI	The National Science, Technology, and Innovation System, Peru
SNICT	National Innovation, Science and Technology System, El Salvador
SPRU	Science Policy Research Unit
SPU	Secretariat for University Policies, Argentina
SSC	Salvadoran System for Quality
STI	Science, Technology and Innovation
STP	Technical Secretariat of the Presidency, El Salvador
TFP	Total Factor Productivity
UNDP	United Nations Development Program
UNESCO	United Nations Education Scientific and Cultural Organization

USAID	United States Agency for International Development
US-NAS	US National Academy of Sciences
UVT	Technological Liaison Units, Argentina
VAR	Value-added Resellers

Introduction to Science, Technology and Innovation Policies for Development: The Latin American Experience

Gustavo Crespi and Gabriela Dutrénit

Abstract Since the pioneering work of Solow (1957), technological change has been credited with explaining a substantial share of economic growth. Indeed, recent evidence for the United States shows that investments in research and development (R&D)—a proxy for the innovation effort of a nation—made up 40 percent of the productivity growth observed during the postwar era (Reikard 2011). Based on these findings, several Latin American and Caribbean countries have established and implemented public policies aimed at enhancing innovation. In practice, the first cases of explicit interventions to encourage innovation emerged even earlier, toward the end of World War II. Although many of these policies were either abandoned or dramatically downsized under the structural reforms inspired by the Washington Consensus, the disappointing results in terms of productivity growth have led several countries in the region to reintroduce policies to stimulate innovation and encourage technology adoption. This introductory chapter outlines the main trends with regards to the design and implementation of Science, Technology and Innovation Policies in the Latin American and the Caribbean (LAC) region, highlighting both convergent and divergent trends among the different countries in the region.

This is a book about the heterogeneity and diversity seen in the design and implementation of Science, Technology and Innovation (STI) policies in the Latin American and Caribbean (LAC) region. Throughout the book we show that STI policy-making is governed by the convergence of the different trends by which

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countries apply new conceptual frameworks. These trends emerge from both outside the region, like the National Innovation System (NIS) approach (Freeman 1987; Lundvall 1992; Nelson 1993; Kim 1997); and from the inside too, such as the Latin American school of thought on science and technology and the structuralist views, among others (Sábato and Botana 1968; Presbich 1949a, b; Furtado 1958, 1961; Herrera 1971; Sagasti 1978). At the same time, countries try to learn from each other to improve their actions, yet we can see diverging trends that result from institutional constraints and differences in political economics, factors that determine the application of these approaches to each particular country. Having said this, the first topic of this introduction is the convergence of said trends and views.

1 A Brief Historical Perspective: More than Half a Century of Experimentation

The experience of the LAC region with regard to the design and implementation of STI policies dates back to the 1950s. Since then, different experiments based on alternative policy paradigms have been followed to promote STI in the region.

1.1 The Supply-Side Approach (1950s–1980s)

The background of this phase dates back to the late nineteenth century when the first engineering schools were established across the region with the particular aim of supplying the human capital necessary for infrastructure deployment (in particular railways and ports) oriented toward the installation of the export-led growth model of development. Since then, it is possible to say that the demand for technology adoption, services, and human capital was strongly influenced by the dynamics of export-oriented industrialization first and by the requirements of the import substitution model afterwards (Sagasti 2011). The conceptual framework that governed this phase was based on the idea of linearity from supply to demand; direct production of knowledge and complementary assets—in particular human capital and information—were dominated by public institutions (e.g. laboratories, research institutes and universities). Intellectual property protection was also weak with the idea of facilitating technology adoption and imitation. The governance of this process was based on the establishment of new institutions: the National Research Councils, with the task of funding research, human capital formation, and establishing science and technology policy frameworks. The support to research and the technical and professional training was complemented with the establishment of technological institutes that were operating at the sector level. They had to fulfill a dual role: to carry out applied research and to transfer knowledge and technologies to the firms operating in strategic sectors.

Institutions such as the National Institute of Industrial Technology (INTI) of Argentina, the National Institute for Agricultural Technology (INTA) of Argentina, the Agricultural Research Corporation (EMBRAPA) of Brazil, the Technological Institute (INTEC) in the case of Chile, the Institute for Industrial Technology and Technical Norms (ITINTEC) of Peru and the National Laboratory for Industrial Development (LANFI) in Mexico are all examples of institutions that fulfilled a role that could be well characterized as the supply of public goods. Several of these institutions played important functions in business innovation, in particular, sectors such as auto-parts (INTI), hybrid corn (INTA), sugarcane (EMBRAPA), the packing industry (INTEC), and industrial technology (ITINTEC) (Rivas 2013).

Consistently with the supply approach, far less importance was put on assisting the development of technological capabilities by the private sector. In fact, the business sector became seriously fragmented between a set of large state-owned enterprises that operated in strategic sectors (mostly in energy, utilities, and heavy industry) coexisting with a scatter set of Small and Medium Enterprises (SMEs) with very low technological capabilities. In this context, R&D labs in public owned enterprises played an important role on technology adoption and innovation in each strategic sector; these are the cases of State firms such as YPF (Argentina); Petrobras and Embraer (Brazil), and Pemex (Mexico). These labs co-existed with a large population of SMEs that under the umbrella of protection and cheap credit followed a quite idiosyncratic model of learning. Later in time, it is observed the arrival of subsidiaries of Multi-national Enterprises (MNEs) that brought to the region state-of-the-art technology mostly developed in headquarters with incremental adaptations to local conditions.

The natural protection given by the disruption of the international trade system during WWII, followed by highs tariffs, import quotas, and the economic recovery after the war, led to many firms to start-up the production of local consumer goods and capital equipment of low complexity based on engineering designs up to two decades behind the international frontier. Although substitution policies were considered temporary and to be dismantled after catching-up with the international frontier, the political economy setting generated by the import substitution process with new alliances between protected entrepreneurs and the new urban proletariat meant that this fine-tuning never happened or at least happened at the right pace (Katz and Kosacoff 2000). In summary, the typical domestic firm from this period can be characterized by its very small scale, a large mix of products, low production efficiency, and high-level vertical integration due to the lack of local suppliers of inputs. These structural characteristics gave place to the identification of numerous bottlenecks that ended up triggering local learning processes (mostly by the setting of ad hoc groups) (Katz 1987). Spillovers were generated across the production structure, mostly due to workers' circulation and professionals' interactions. Processes of learning as those described here are also observable among the successful Asian Tigers; the difference is mostly seen in the local conditions within which these learning processes took place, and, particularly in the case of LAC, in the lack of provision of important complementary inputs such as human capital, the absence of sector-wide technological infrastructures for technology

diffusion and capacity building, and the lack of incentives from product market competition. From an institutional viewpoint, key players from the public sector were Ministries of Education and Industry, National Research Councils, National Development Banks, and Foreign Direct Investment (FDI) boards. Regarding the private sector, an increasing number of Business Associations and Unions can be seen as having some role. However, the overall policy framework can be characterized as top-down with weak vertical and horizontal coordination and little public–private interaction.

1.2 Pushing the System Toward a Demand-Side Approach (1980s–2000s)

This phase is dominated by the structural reform programs implemented under the inspiration of the Washington Consensus approach. The main vehicles of these reforms were trade liberalization, financial liberalization, privatization, and neutrality in policy intervention. The diagnosis was that the lack of success of the previous phase were related to excessive government intervention and government failures, and that, to avoid this, it was better to keep intervention at its minimum expression. The assumption was that a minimalistic government would "*free the productive forces*" of the business sector. The Washington Consensus approach had important implications for innovation policy. Indeed, the majority of the public organisms and institutes related to the promotion of innovation lost importance within the bureaucratic structure of the state. Public budgets for supply-side organizations were severely curtailed, new incentive regimes were established to introduce market discipline in technological institutes (so these institutions had to dramatically increase their external funding through the selling of normalization services to the private sector), human capital formation was deregulated and private universities entered into the market, intellectual property frameworks were gradually strengthened, etc.

The structural reforms had also important consequences for the innovation model followed so far: (i) imported capital goods become cheaper so inducing an important substitution of locally produced by foreign sourced machinery and equipment. This led to a process of technology modernization at large in the production structure but to a destruction of an important part of the local industry of technology; (ii) most of the imported capital goods embodied the diffusion of Information and Communication Technologies (ICT), which required changes in work organization to be useful and the implementation of organizational innovation; (iii) the reconfiguration of global production chains led to the specialization of MNEs subsidiaries in few global products of the MNEs production mix, becoming importer of the rest; (iv) the privatization of public enterprises led to the closing of corporate R&D labs and to a drastic reduction in engineering expenditures; (v) organizational innovation in SMEs led to vertical disintegration and increase assembly of imported components, and (vi) gradual emerging of a sector of

knowledge intensive SMEs specialized in ICT services and software focused on the development of applications adapted to the local conditions (Katz and Kosacoff 2000). All these changes occurred also during times of dramatic acceleration of productivity growth at the technological frontier (Sagasti 2011). It is ironic that at the same moment when the demand was suffering an important reconfiguration, when the needs for technology adoption increased and when the incentives to innovation on demand-side were supposed to be enhanced (mostly through product market competition), the support to the supply-side of the equation was being dismantled.[1]

In summary, the main public goods horizontal policies during this period were the deregulation of the higher education system, the downsizing of the support to scientific research, together with a shift in its financing model (towards competitions and call for proposals), strengthening of intellectual property rights and the overall business climate. With regard to public goods-vertical policies, there was a downsizing of the budgets of the technological institutes and even some of them were closed down (such are the cases of ITINTEC in Peru, INTEC in Chile, and LANFI in Mexico). For the remaining ones there was a push led by changes in the financial mechanisms to become suppliers of metrology and quality control services. With regard to vertical/market intervention policies, there was a remarkable withdrawal of programs and policies (mostly the result of the trade openness and privatization).[2]

The pitfalls of the approach became evident toward the end of this phase when it was clear that market failures related to innovation persisted (even when this innovation was adaptive), and externalities, and the lack of complementary assets and of financing continued to be important obstacles for firms that were trying to adapt to the new scenario. As a reaction to this, and based on the reviewed of successful cases of catching-up, such as Finland and Israel, some countries started with the experimentation of horizontal/market intervention policies. Indeed, borrowing heavily on the Israeli Office of the Chief Scientist (OCS) model of horizontal technology policy, subsidies for business R&D, R&D tax credits, conditional loans, and vouchers for technology transfer were introduced since the second half of the 1990s. Most of these programs were delivered through the installation of an institutional innovation: the Technology Development Fund (Bravo-Ortega and García 2007). Although in many cases these funds were initially established in already existing institutions such as development agencies or research councils, there was a growing institutional specialization leading to the spin-off of dedicated agencies or funding units. The policy framework of this period can be characterized as one which is bottom-up, with weak vertical and horizontal coordination but with increasing experiments of public–private interaction.

[1] This strongly contrasts whit the evidence from Finland and Israel commented below.

[2] Some exceptions to this are the car industry regime in the case of MERCOSUR and the support to the Aerospace, Ethanol, and Electronic industries in the case of Brazil that although there were some changes in the instruments the strategic focus in these sectors remained.

1.3 The Systemic Approach (Since 2000s)

The need to improve competitiveness and to scale-up business innovation support led toward the end 1990s to the search for new approaches. There was a growing consensus on the fact that business innovation support with a strong focus on the individual firm was not enough to internalize spillovers and solve coordination failures. The evidence on the main building blocks and best practices about the determinants of innovation success in catching-up economies led to an increased interest in the roles that the research and human capital building systems had in this process. The diffusion of the innovation system concept triggered a renewed interest in investing on the supply-side of the equation but now with an increased concern on generating the right incentives to favor a closer articulation between supply and demand. So, this phase gave place to a new period of policy learning and experimentation. The originally simple Technology Development Fund model is becoming increasingly complex with the appearance of new policy instruments aimed at generating thematic funding for research, scholarships for advanced human capital in science, technology, engineering, and mathematics, grants to stimulate university–industry collaboration, the formation of technological consortiums, and the financing of technology-based entrepreneurship. New institutions such as technology liaison offices specialized in linking the different actors of the system also become part of the scene. After many years of inaction there was also a return of interest in supporting technology extension, now with a focus on building innovation capabilities in SMEs. On the top of strengthening the technological institutes there is a growing interest in establishing "systemic" approaches to technology transfer where programs aim at the articulation of technological institutes, private providers of technological services and firms.

A second feature of this phase is the increasing interest for the support of vertical policies. The main rationale for this was that although horizontal policies had the advantage of allowing the exploration of the production landscape at large, on the other hand, successful exploration also requires the implementation of large-scale support programs, something that was not feasible given the financial constraints of the public sector. In other words, there is the concern that a combination of "exploration at large" with "budgets in the small" might lead to problems of critical mass and loss of synergies among projects. Thus, since the early 2000s there is a growing concern for putting in place vertical programs both with public good provision features (mostly through the support of technological consortiums) and in the market intervention domain (targeted subsidies). In the last case, countries started experimenting with mission-oriented funds where public procurement is important (such as programs in health and energy) and target subsidies toward technologies (and indirectly originator sectors) in GPTs (*General purpose technologies,* that is, technologies than can spread out across the production sector at large).

The multiplication of programs with very different designs and the appearance of new implementing agencies (e.g., SMEs authorities) led to increased institutional stress and the need to improve policy coordination. And so new institutional

models were put into place, and the policy framework became two-fold: top-down/bottom-up (due to the increase interest about vertical programs), there is a stronger concern for improving vertical coordination (stronger Ministries of Science and Technology and Innovation Authorities), and stronger horizontal coordination (through Ministerial Cabinets of Science and Technology and Innovation Councils). It is important to say that the current (more systemic?) phase of innovation policies operates within a context of open economies, macro stability, and excellent external conditions that facilitates the relaxation of fiscal constraints, so that there is an appetite for learning and experimentation. The trends of the design and implementation of STI policies in LAC countries have followed with some delay the dynamics of the policies introduced in developed countries. The reproduction of designs based on countries with more mature NIS or the experience of successful emerging economies (such as Korea, China, Singapore) could hardly be successful in a region with different initial conditions. LAC have a highly uncertain evolution of the macro, high inequality, a rather less consolidated scientific base, a narrow base of firms that perform R&D, and in general lack what Guston (2000) has called a social contract of S&T with society. For these and other reasons, the recommendations that emerged from successful cases intertwined with the own efforts of the region to think from its realities, have not showed a clear path to follow. As argued by Rodrik (2007), the same recipe does not work in different institutional buildings and policies' paths.

Nowadays, the current institutional framework is a hybrid that results from different layers of institutions and policy instruments, some of them managing to survive from the old times of science policy (e.g., the research councils), which coevolve with new actors (the innovation agencies) and bridge institutions.

2 LAC Innovation at Glance

The Latin American NIS are small, according to the size of the main actors and the articulation they have established. Only recently, technical change based on local and systematic STI efforts has begun to be identified as an important factor to improve the productivity and welfare of the LAC economies (Dutrénit and Sutz 2014). The financial resources dedicated both by the public and private sectors to STI are still scarce, in fact, it seems that the most productive activities in the LAC markets (at the industrial or service levels) have no relation to innovation efforts, that is, the signs of short-term relative gains appear to be disassociated from innovation (Cimoli 2000; Cassiolato et al. 2003; López 2007; Dutrénit et al. 2010).

The past evolution of STI policies together with its marginal roles first as an appendix of industrial policy and then as an appendix of the market, has led to a situation where: (a) the region as a whole invests very little in intangible investments; (b) there is a dramatic deficit in investment from the private sector, public sector remains the main source of funding for R&D (53.4 % in 2009 as an average

for LAC); (c) the region is still a technology adopter and there are very little signs of improvement (according to regional data on the technology balance of payments as percentage of Gross Domestic Product [GDP], the LAC region had an indicator of −0.11 % in 1998 and −0.09 % in 1998[3]); (d) all the countries invest in R+D less than it is expected given their current level of development (i.e., the GERD as percentage of GDP in 2010 was 0.47 % for Mexico, 0.61 % Argentina, 0.40 % Uruguay, and 0.19 % Colombia, in contrast Brazil had a remarkable performance for the region with 1.16 %, while Korea reported 3.74 % and the average of the European Union was 1.91 %[4]); (e) there is a small scientific community with level of excellence in some scientific fields in the largest countries, centered on curiosity-driven research, and with few incentives to develop research oriented toward national problems, but with experience in solving some specific problems related to health, environment and food; research productivity is very low (i.e., in 1996–2011 lapse, the percentage share of LAC scientific publications in the world was 3.1 %, while U.S. had a percentage share 23.8 %, U.K 6.6 % and France 4.4 %. Taking into account the scientific documents published in SCOPUS as percentage of 1,00,000 inhabitants, the countries behave differently, 340 in Chile, 258 in Argentina, 249 in Uruguay, 199 in Brazil and 126 in Mexico, while the average of the European Union was 1,761[5]); (f) technological productivity is rather low and there is a dramatically low conversion rate of research outputs into technology outputs and innovations (i.e. Total Patent Applications in LAC was 2.5 % in 2011[6]); and (g) high geographical and institutional concentration of STI capacities. Overall this is related with a relatively good rate of growth in many countries, even during the last international crisis (the GDP growth rate from LAC region was 3.0 % between 2000–2010, Chile 3.8 %, Uruguay 2.9 %, Brazil 3.6 %, Mexico 1.8 % and European Union 1.4 %[7]) but a dramatically bad productivity performance of the economies (i.e., the productivity relative to the US in 2011 was 0.19 % for Chile, 0.28 % for Mexico, and 0.19 % for Brazil).

3 Objective of the Book

The aim of this book is to shed light on the current state and recent evolution of the STI policy-making process in Latin America. STI institutional frameworks have evolved through major transitions in the region over the last 30 or 40 years, however, during the last decade there has been a growing convergence across the region toward the implementation of institutional frameworks that

[3] World Bank, World Development Indicators.

[4] OECD, Main Science and Technology Indicators database.

[5] SCIMAGO, Research Group, Journal & Country Rank.

[6] WIPO, Statistics database.

[7] World Bank, World Development Indicators.

enhance interaction and collaboration among the different actors (government, firms, and research centers) of the innovation system, converging toward the so-called systemic/evolutionary approach to STI policy (Nelson 1994; Breznitz 2007; Smits et al. 2010; Dutrénit et al. 2011). Transversality, seen as coordination between ministries and the STI agency, began to emerge as a feature of STI policies (Kuhlmann 2001; Georghiou 2001; Shinn 2005; Cooke 2011). Having said this, on the other hand, there is growing divergence on the institutional frameworks that regulate the STI policy-making process across the region. Some countries have established Presidential Councils for STI policies, other countries have put into place new actors such as specialized agencies, while other countries have opted for giving additional functions to already existing institutions. Institutional reforms have also been accompanied through an increasing number of experiments in terms of new instruments or interventions. Despite this there is still a lack of comparative evidence that sheds light on the pros and cons of the different institutional reforms and on the impacts that this is having on the effectiveness of the policy-making process in the STI arena.

Based on the belief that different groups of countries in the LAC region require different policy approaches and different combinations of instruments, this book collects the experiences of eight LAC countries with different approaches regarding STI policy making. This illustrates the heterogeneity and diversity of the region as well as the convergence and divergent trends referred to above. The book also includes two comparative chapters looking at similarities, learning experiences, and policy impacts of STI policies across the countries. In summary, the book will gather lessons learned through the institutional reforms, the changes in governance, and the policy impacts that will greatly enrich not only the quality of the training of new scholars in the area of STI public policies, but also provide them with examples and recommendations emerging from successful and unsuccessful cases from within the region. Additionally, this book will provide critical input for current policy makers who seek for new evidence on impacts or lessons learned from institutional reforms carried out in other countries in the same region. Thus, it is also expected that this book will encourage collaboration among policy makers within the region. The experiences discussed here may also be of interest for international institutions that advise the LAC region and other developing and emerging regions.

4 Book Content

"The Changing Role of Science, Technology and Innovation Policy in Building Systems of Innovation: The Case of Mexico" aims to analyze the main features and the evolution of STI policy in Mexico for the last decade. To this end, five relevant and interrelated issues for understanding STI policy in Mexico are discussed. First, an outline of the distinctive characteristics of the Mexican innovation system and its implications in terms of STI policy design and implementation.

Second, the tension between policy design and its implementation, and in particular the relation between the model of STI policy that arises from theoretical and empirical paradigms in developed countries, and the national context of Mexico. Third, an analysis of the pertinence of STI policies is undertaken, in other words, to what degree the policy-mix in Mexico has been appropriate in terms of the desired objectives. Fourth, the nature of the governance as a central issue in the performance of the system. In this respect the study focuses not just on the interrelation between government-governance, but advances in exploring how this interrelation has influence and in some way determines the implementation and the evolution of Mexico's STI policy. Finally and in line with the modern development theory, Corona, Dutrénit, Puchet, and Santiago argue how Mexican STI policy has systematically neglected its impact on the achievement of more equitable and inclusive economic and social development. The authors argue for the need to adopt a new perspective on STI policy design in order to incorporate as a key issue, the pursuit of better life standards for Mexican people in the context of and inclusive of social development.

"Insights into the Impact of BID's Technology Modernization Program on Argentina's STI Policy" explores the evolution of the institutional systems and bodies of policy regulation, planning, and coordination in Argentina in the last decades, and analyzes new instruments for the promotion of scientific research and technological innovation that were incorporated in the productive sector. Particular attention is given to the institutional building process and a major step in 2007 with the creation of the Ministry of Science and Technology (MINCyT), incorporating the National Agency of Scientific and Technological Promotion (ANPCYT) as a decentralized body. Lugones, Porta, and Codner also analyze the results of the Technological Modernization Program (PMT), which evolved through three phases. Based on the evidence of a relatively isolated execution of resources allocated to PMT III in relation to other existing instruments, this paper claims the need to better articulate the STI policies into a more coherent policy mix to rationalize and enhance the different public instruments available.

"Evolution of the Public Institutions of Science, Technology, and Innovation in Chile: 1990–2012" makes a historical review of the Chilean institutional development, emphasizing the virtues and deficiencies of each stage and illustrating the way in which the Chilean system of public support has evolved up until this day. It was one of the first LAC countries that installed a system to assist science through annual competitive funds with peer evaluations. The program FONDECYT was implemented in the mid-1980s in the CONICYT and consisted of a direct subsidy to individual researchers aimed at generating advances in knowledge in multiple areas without a pre-established subject bias. Afterwards, thanks to a loan from the Inter-American Development Bank (IDB), support programs for associative research and entrepreneurial innovation were implemented. These two programs were the origin of what is known today as the Innova program under the Chilean Economic Development Agency (CORFO). Recent evaluations show that these proposals were key in order to improve the scientific and technological indicators of the country, although they remain pretty low compared to other countries with

a similar income. The document of Benavente and Price describes other important steps in the institutional building process. First, the promulgation of a law in 2005 that charges a tax on national and international copper mining firms' sales, and defines the use of these resources toward the support of scientific and innovation activities in the country. That is how the baseline of STI funding emerges. Second, the creation of the National Innovation Council for Competitiveness (CNIC), which contributed to the definition of a long-term strategy.

"Inclusive Innovation Against all Odds: The Case of Peru" indicates that even though Peru is one of the Latin American countries that has stood out for experiencing a sustained economic growth in the last decade, little attention was given to STI until very recently. In the last 5 years some STI instruments have begun to be implemented, highlighting the launch of the Fund for Innovation, Science and Technology (FINCYT). The lack of human resources in STI policies design and implementation contributes to explain the difficulties to translate into clear policies the declaration concerning the important role of STI for development. Kuramoto's paper discusses the lack of direct connection between the Peruvian STI and social inclusion policies over time, and recent efforts to use some technology transfer programs to deliver some benefits to poor populations while strengthening production chains or conglomerates.

"From Design to the Institutional Construction of a Policy for Science, Technology and Innovation in El Salvador" offers a revision of the public policy efforts made in El Salvador in recent years in order to generate the proper institutional environment to promote activities of STI, and to design an appropriate policy mix, which includes technological and sectorial funds, programs to foster university–industry linkages, and even initiatives to generate risk capital by the new Development Bank (BDESAL). López-Martínez and Hernández emphasize the flaws and weaknesses as well as the lessons learned, on one side the successes are related to the redesign of institutions and policies of support for STI, but the main problems and weaknesses are located in the implementation, monitoring, and definition of the appropriate performance indicators and then the evaluation of the results.

"Value Attributed to STI Activities and Policies in Uruguay" analyzes the process of revaluation of STI at the level of public policies in Uruguay that started in 2005 and continues to this day. Bianco, Bianchi and Snoeck examine how this process is expressed in legal and institutional reforms accompanied by a significant increase of budget resources, as well as a larger presence of the STI in the public policy discourse. This study also ponders how this process of revaluation is articulated with the perception and valorization of the scientific-technological knowledge and innovation in society in general and in different aspects of the economy in particular. This analysis is focused on both the perception of the importance of STI for productive processes in some selected branches of the industrial and agricultural sectors, and on the other hand, the perception of citizens on the activities of STI in the country.

"Innovation, Production and Innovation Systems and the BNDES' Contribution" discusses the concept of innovation in a LAC context and, based on that, explores the Brazilian experience of designing and implementing policies

to foster innovation and production systems and arrangements. This approach includes agents and activities of both production and innovation, which have different trajectories and dynamics, from knowledge intensives to those that use traditional knowledge, operating at local, national, or international levels. Lastres, Garcez, Lemos, Barbosa, and Magalhães focus specifically on the experience of the Brazilian Development Bank (BNDES) in providing support for innovation, regional development, and Local Production and Innovation Systems. Finally, they address some implications of the financing schemes to support innovation for the theory and policies.

"Policy Coordination: From FDI to a Broader Framework to Promote Innovation—The Case of Costa Rica" asserts that in recent decades, Costa Rica viewed FDI attraction as a strategic option to sustain growth, promote structural change, and create better jobs. The successful record of FDI investment in the country fostered profound changes in the country's trade specialization, inducing derived demands for new and better skills in the population, and wider availability of entrepreneurial and technical capabilities in specific industrial clusters. However, the linkages between local and foreign companies in Costa Rica are still weak, and R&D and innovation investments are coming short for the country needs. Thus the country has been shifting gradually toward a more selective policy approach to FDI by targeting certain knowledge-intensive sectors, while some global firms have recently moved toward more sophisticated activities in the country. Public institutions like the Costa Rican Investment Promotion Agency (CINDE) have earned a reputation for their success in attracting high tech FDI, their coordination capabilities across the public sector, and their timely response to specific private demands. Similarly, the more recent creation of the Presidential Council for Competitiveness and Innovation (PCCI) in 2010 aims at improving the governance of this new approach to development, through the coordination of the needed policies. Monge-González and Tacsir discuss to what extent the national policies and institutions have so far contributed to promote the exhibited upgrading of local operations, and the current efforts to move to a wider development strategy, where the focus is on knowledge intensive activities and innovation.

"Design and Evaluation of Fiscal Incentives for Business Innovation in Latin America: Lessons Learned After 20 years of Experimentation" reflects on the fact that since the beginnings of the 1990s, many LAC countries show a systematic growth of the public programs destined to foster innovation and technological modernization of firms. The justification of these programs is the incapacity of the market to provide the necessary incentives in order to reach an acceptable level of private investment in innovation activities, as a result they have not adopted the technologies and modern productive practices that would have allowed them to improve their productivity and competitiveness. In this context, a number of LAC countries have introduced programs of fiscal incentives in order to stimulate the innovation activities and strengthen the links between firms and other agents of the NIS. The first program of this type started in Chile in 1991 and ever since has generalized to the entire region; nowadays about 70 % of the LAC countries implemented some kind of fiscal stimulus program for private investment

in innovation. Along with the accumulated experience with the implementation of these programs, in recent years there has emerged an important amount of evidence and methodological learning about its effectiveness in order to mitigate the different market failures that make innovation and productivity in the region difficult. Crespi and Maffioli conduct a qualitative meta-analysis of these programs and their respective impact evaluations in order to take stock of the learning achieved and to present specific recommendations on how public policy should be designed to maximize its impact on business investment and productivity.

Finally "Science, Technology and Innovation Policies for Inclusive Development: Shifting Trends in South America" stresses the relevance of studying the connection between STI policies and inclusive development. Bortagaray and Gras explore the current STI plans of Bolivia, Colombia, Ecuador, and Peru, and focus on how STI policy is framed and connected to the broader discussion on STI for inclusive development. The evidence shows that traditional knowledge and know-how toward the search of solutions for national and local problems are at the center of the discussion. These shifts in STI policy frameworks are still in the planning phases, but deliberation and participation seem to be crucial for building capabilities and expanding the choices about STI policies for development goals.

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References

Bravo-Ortega C, García A (2007) Cerrando la Brecha Innovativa Latinoamericana: ¿Qué podemos aprender de Corea, Israel y Finlandia? Serie Estudios Socio Económicos 35:3–43

Breznitz D (2007) Industrial R&D as a national policy: Horizontal Technology Policies and Industry-state coevolution in the growth of the Israeli software industry. Res Policy 36:1465–1482

Cassiolato J et al (eds) (2003) Systems of Innovation and Development Evidence from Brazil. Edward Elgar, Cheltenham

Cimoli M (ed) (2000) Developing Innovation Systems. Mexico in the Global Context. Pinter, London

Cooke P (2011) Transversality and regional innovation platforms. In: Cooke P et al (eds) The Handbook of Regional Innovation and Growth. Edward Elgar, Cheltenham

Dutrénit G et al (2010) El Sistema Nacional de Innovación Mexicano: Instituciones, Políticas, Desempeño y Desafíos. UAM-X/Textual S.A, Mexico

Dutrénit G et al (2011) Building bridges between co-evolutionary approaches to science, technology and innovation development economics: an interpretive model. Innovation and Development 1(1):51–74

Dutrénit G, Sutz J (2014) Innovation Systems for an inclusive development: the Latin American Experience. Edward Elgar, Cheltenham (forthcoming)

Freeman C (1987) Technology, policy and economic performance: lessons from Japan. Pinter, London

Furtado C (1958) Capital formation and economic development. In: Agarwala A, Singh SP (eds) The Economics of Underdevelopment. Oxford University Press, Oxford
Furtado C (1961) Desenvolvimento e Subdesenvolvimento. Fundo de Cultura, Rio de Janeiro
Georghiou L (2001) Evolving frameworks for European collaboration in research and technology. Res Policy, 30(6):891–903
Guston DH (2000) Retiring the social contract for science. Issues Sci Technol 16
Herrera A (1971) Ciencia y política en América Latina. Siglo XXI, Buenos Aires
Katz J (ed) (1987) Technology Generation in Latin American Manufacturing Industries. MacMillan, London
Katz J, Kosacoff B (2000) Globalización, Reformas Estructurales y Sistemas Innovativos. ECLAC Review 75
Kim L (1997) From Imitation to Innovation: The Dynamics of Korea's Technological Learning. Harvard Business School Press, Boston
Kuhlmann S (2001) Future governance of innovation policy in Europe: three scenarios. Res Policy 30(6):953–976
López A (2007) Desarrollo Económico y Sistema Nacional de Innovación en la Argentina. Consejo Profesional de Ciencias Económicas de la Ciudad Autónoma de Buenos Aires, Buenos Aires
Lundvall B-A (1992) National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning. Pinter, London
Nelson RR (ed) (1993) National Innovation Systems: A Comparative Analysis. Oxford University Press, New York
Nelson RR (1994) The coevolution of technologies and institutions. In: England RW (ed) Evolutionary concepts in contemporary economics. University, Ann Arbor, p 139–156
OECD (2013) Main Science and Technology Indicators. https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB
Presbich R (1949a) O desenvolvimento económico da América Latina e alguns de seus problemas principais. In: Bielschowsky R (ed) Cinquenta anos de pensamento na CEPAL. Editora Record, Rio de Janeiro
Presbich R (1949b) Problemas teóricos e práticos do crecimento económico. In: Bielschowsky R (ed) Cinquenta anos de pensamento na CEPAL. Editora Record, Rio de Janeiro
Red de Indicadores de Ciencia y Tecnología Iberoamericana e Interamericana (2013) RICYT. http://www.ricyt.org
Rivas G (2013) Instituciones y políticas para impulsar la innovación en América Latina y el Caribe. Monograph. CIEPLAN, Santiago de Chile
Rodrik D (2007) One Economics, Many Recipes. Globalization, Institutions and Economic Growth. Princeton University Press, Princeton
Sábato JA, Botana N (1968) La ciencia y la tecnología en el desarrollo futuro de América Latina. In: Sábato JA (ed) El pensamiento latinoamericano en la problemática ciencia-tecnología-desarrollo-dependencia. Paidós, Buenos Aires
Sagasti F (1978) Ciencia y tecnología para el desarrollo: informe comparativo central del proyecto sobre instrumentos de política científica y tecnológica (STPI). Centro Internacional de Investigaciones para el Desarrollo (CIID), Bogota
Sagasti F (2011) Conocimiento y Desarrollo en América Latina: Antecedentes, evolución y prspectivas de las políticas de ciencia, tecnología e innovación. Fondo de Cultura Económica, Mexico
SCIMAGO Journal & Country Rank (2013) Scimago Lab. http://www.scimagojr.com/index.php
Shinn T (2005) New sources of radical innovation: research-technologies, transversality and distributed learning in a post industrial order. Soc Sci Inform 44:731
Smits R et al (eds) (2010) The Theory and Practice of Innovation Policy. An International Research Handbook. Edward Elgar, Cheltenham
IP Statistics Data Center (2013) WIPO. http://ipstatsdb.wipo.org/ipstatv2/ipstats/patentsSearch
World Development Indicators (2013) World Bank. http://databank.worldbank.org/data/views/variableSelection/selectvariables.aspx?source=world-development-indicators

The Changing Role of Science, Technology and Innovation Policy in Building Systems of Innovation: The Case of Mexico

Juan Manuel Corona, Gabriela Dutrénit, Martín Puchet and Fernando Santiago

Abstract Latin American countries still account for most of the world's social challenges: extreme poverty, malnutrition, high infant mortality, low life expectancy and a decline in schooling quality indicators. For many countries, Mexico included, a number of these problems can be traced to income inequality, a low-qualified workforce, increasing presence of informal sectors and the dominance of economic structures heavily dependent on low-intensive technological sectors. Limited investment in science, technology and innovation (STI) also remains a salient feature of these economies. In this regard, a growing stream of literature has drawn attention for linking STI to broader economic and developmental agendas (Kraemer-Mbula and Wamae in Innovation and the Development Agenda, OECD, Paris, p. 152, 2010; Gault, Innovation Strategies for a Global Economy, Edward Elgar, Cheltenham, p. 232, 2010; STEPS, Innovation, Sustainability, Development: A New Manifesto, The STEPS Centre, Brighton, p. 24, 2010). In many instances, the bid is for the review and renewal of the relationship between STI activities and the overall social and economic dynamics of countries (Azzazy, Science, 333(6040):278–284, 2011; Cozzens and Sutz, Innovation in Informal

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Settings: A Research Agenda, p. 53, 2012). From the National Innovation System (NIS) perspective (Freeman 1987; Lundvall 1992, 2010; Nelson 1993; Edquist 1997, 2006), STI policy has been crucial as a means for development and consolidation of NIS's agents both in academia and the productive sector, as well as in incentivizing a dynamic interaction between them. Likewise, important for STI policy is to promote and sustain the creation, dissemination and use of knowledge as an interactive, self-reinforcing mechanism guiding the generation of STI capacities, the operation of and governance of the STI system and its correspondence with the dynamics of social and economic systems. Public policy in general and STI policy in particular shape and reshape the institutional framework in which the system's agents perform, and at the same time, the institutional framework sets some boundaries to the unfolding of public intervention. This chapter analyses how public policies have contributed, or not, to the building and nurturing the Mexican System of Innovation, and how the emergent system feedbacks the design, tailoring and implementation of STI policies in Mexico. We also consider the institutional environment in which the NIS performs, the mechanisms governing public funding, as well as the configuration of the policy mix, as a fundamental part of the public action that seeks to influence the social and economic dynamics of the country. The analysis is focused on how the policies, the system and the institutional environment have co-evolved since the 1940s.

1 Introduction

Latin American countries still account for most of the world's social challenges: extreme poverty, malnutrition, high infant mortality, low life expectancy rates and a decline in schooling quality indicators. The situation is exacerbated by economic, political and institutional factors such as growth population, rapid urbanization, persistent vulnerability to natural disasters, persevering macro-instability, institutional weaknesses, lack of civil rights, environment deterioration and rampant criminality. For many countries, Mexico included, a number of these problems can be traced to income inequality, economic structures heavily dependent on low-intensive technological sectors (primary sectors, traditional manufactures and simple-service sectors), low-qualified workforce and an increasing presence of informal sectors, all of this marked by low productivity. Limited investment in science, technology and innovation (STI) remains a salient feature of these economies.

Nonetheless, over the past two decades, the global economy has changed as a selected group of large and dynamic developing countries—India, China, Brazil—and, in some aspects, Mexico—experienced a steady and decisive growth in both economic and political powers (Scerri and Lastres 2013; The Economist 2012). These emergent economies have supported part of their economic success on the introduction of significant institutional changes oriented towards stimulating STI (UNESCO 2010). Increasing investments in STI in order to enhance productivity, economic growth and competitiveness are pervasive, as STI is expected to provide

some solutions to a number of pressing social and economic challenges both in developed and developing countries (OECD 2010, 2012; STEPS 2010).

In this regard, a growing stream of literature is drawing attention for linking STI activities to broader economic and developmental agendas (Kraemer-Mbula and Wamae 2010; Gault 2010; STEPS 2010; Arocena and Sutz 2012; Hawkins 2012). In many instances, the bid is for the review and renewal of the relationship between STI activities and the overall social and economic dynamics of countries (Azzazy 2011; Cozzens and Sutz 2012; STEPS 2010).

During the past decade, some emergent countries, including Mexico, have embarked in a reform of their National Innovation System (NIS) in order to enhance scientific, technological and innovation capabilities; particular emphasis has been placed on the role that public policy intervention plays in transforming NIS in developing countries (Dutrénit 2012; Scerri and Lastres 2013). So much so, that as Hawkins (2012) asserts "Investing in science and technology is no longer something that governments must justify—indeed, most would probably have to justify *not* investing." (p. 7).[1]

From the innovation system perspective (Freeman 1987; Lundvall 1992, 2003; Nelson 1993; Edquist 1997, 2006; Metcalfe, 1994), modern approaches to STI policy regard policy intervention as a means for development and consolidation of a dynamic set of interactions between a number of agents in academia and the private sector. Interactivity is a necessary ingredient for a sound and well-performing NIS. Likewise, important for STI policy is to promote and sustain the creation, dissemination and use of knowledge as an interactive, self-reinforcing mechanism guiding the generation of STI capacities, the operation of and governance of the STI system and its correspondence with the dynamics of social and economic systems. STI policy informs the institutional set-up—common social norms that guide behaviours and interactions among those agents (Edquist 2006)—that guides the performance of agents within the NIS. The institutional set-up in turn may either support or hinder the performance of the system, by influencing agents' decisions about the resources they channel, priority setting and resource allocation among different STI activities and so on.

However, building and changing institutional settings are harder and slower process than changing public policy. Norms and rules are embedded in the structure and functions of social systems operating in scientific communities, universities, research centres, private organizations and other agents of the system. The agents' behaviour is strongly governed by norms and rules, which result from a specific social, historical and cultural development, but at the same time, they play a central role in shaping and directing societies. In the same way, the incentive system at the macro-, meso- and micro- levels has a central role in the behaviour of individual agents (Laffont and Martimort 2002). Therefore, without taking into account these regards, attempt to replicate the agents' behaviour and performance based on a particular STI policy model might fail, even if new principles, objectives and practices are generally accepted.

[1] Stress in the original by the author.

The NIS perspective contributes to a better understanding of the role that government and governance play in the STI public policy processes. For instance, it allows the analysis of the governance of the STI system, understood as the different ways of governing the activities of the system through actions taken in accordance with laws, norms and other legal regulations; the mechanisms and channels used by the government and actors to exert their authority and commitments regarding the existing guidelines, programs and ongoing projects; and the degree to which individuals, organizations, associations and consortia emerging either from society or from State bodies respect formal and informal institutions (Puchet and Ruíz 2002).[2]

Along with the concept of governance, modern STI policy models suggest that the systems of government with successful policies result from the interaction of multiple organized agents and not from the unitary action of a central government. This implies a new organization of agents and resources through consensual priorities and interactions that will form networks where participants possess a high degree of autonomy (Casalet 2006; Valdés 2008).

Based on the above, the key questions set down in this chapter are how public policy contributes, or not, to the building and nurturing of NIS, and how the emergent system feedbacks the design, tailoring and implementation of STI policies. Public policy in general and STI policy in particular shape and reshape the institutional framework in which the system's agents perform. At the same time, the institutional framework sets some boundaries to the unfolding of public intervention. The interplay among STI policy, innovation systems and institutional settings is crucial in understanding the co-evolution of these three elements (Sotarauta and Srinivas 2005; Smits et al. 2010).

The chapter explores the complex role of STI policies and the construction and functioning of the NIS in Mexico. In particular, it analyses how STI policies in Mexico have shaped the characteristics of the NIS and the institutional environment within which STI activities take place. The chapter also considers the institutional environment in which the NIS performs, the mechanisms governing public funding, as well as the configuration of the policy mix, as a fundamental part of the public action that seeks to influence the social and economic dynamics of the country. The analysis tries to shed light on how the policies, the system and the institutional environment have co-evolved since the 1940s.

The remainder of the chapter is divided as follows: Sect. 2 presents a brief account of the period 1940–1970 when most of the current agents, social norms and science and technology (S&T) infrastructure began to emerge. Sections 3 and 4 describe major historical moments for both STI policy and the NIS in Mexico. These are the years of the emphasis on S&T with innovation slowly making its way into official discourse much later in the period. These are also years marked by the creation of

[2] According to the Worldwide Governance Indicators, "… governance is comprised by the traditions and institutions through which authority is exercised in a country. This includes the process through which governments are elected, controlled and replaced; the capacity of the government to formulate and apply efficiently the right policies and the respect of the citizens and the state for the institutions that govern the economic and social interactions among them." (World Bank 2012).

basic research infrastructure, including a complex set of public research organizations, which functioned according to dominant linear paradigms for S&T and thus for the design and implementation of S&T policies; and heavy investment in the creation of a sound base of highly qualified human resources. This discussion sets the stage for the analysis in Sect. 5, which deals with the efforts towards the reform and transformation of the Mexican NIS over the last 12 years or so. This recent period is characterized by the recognition of innovation as an activity in its own right, the search for increased interactivity within the system, as well as the building-up of the system governance. The discussion highlights some of the tensions and challenges faced by the process of reform, many of which result from the historically shaped structure of Mexico's NIS. Finally, Sect. 6 presents some conclusion remarks, summarizing the main facts on the co-evolution between, STI policies, the National Innovation System and the institutional framework.

2 The Import Substitution Model and the First S&T Agents (1935–1970)

The NIS as well as the institutional framework within which it develops are the result of a long, cumulative process in which policies, agents and institutional framework co-evolve and feedback on each other.[3] The social, economic and political developments of the country also play crucial roles. This is more evident in the early stages of development of the system.

The creation of an NIS results from the action of multiple actors and factors, including: the application of explicit or implicit (policy actions and decisions not codified in official documents) S&T policies or both[4]; and the implementation of other types of public policies that guide industrial, economic, education, commercial, fiscal and other relevant activities. These policies contributed to the formation of the agents of the system, influencing their characteristics, behaviours and performance. The less explicit and robust S&T policies were the more the influence of other of public policies and factors on the NIS agents' nature and their corresponding interactions.

The origin of some central agents of the Mexican NIS dates back to the early twentieth century with the creation of the National University of Mexico (1910)—which eventually became the National Autonomous University of Mexico (UNAM), the University of San Nicolás Hidalgo, Michoacán (1917) and the University of Guadalajara (1925) among other institutions of higher education.

[3] In this historical period, both in Mexico and in Latin America, the concept of S&T system was used. In the 2000s, the concepts of CTI and NIS began being discussed. Throughout this chapter, the concept of NIS is used.

[4] In this period, reference was made to S&T policy in Mexico and Latin America. It was only by the end of the 1990s that the concept of innovation was introduced, hence adoption of the more familiar reference to STI policies. The discussion in this chapter captures this historical development to denominate policies around scientific, technological and innovation activities.

However, it was only by 1935 that a more formal institutional and policy building process started to lay the foundations of an NIS in Mexico.

Between 1935 and 1970, Mexico adopted an economic strategy that privileged a rapid industrialization process based on the model of import substitution. Although the strategy excluded an "explicit" S&T policy, in practice, it did not preclude the development of some elements of the NIS. The Mexican government, either under the pressure or in coordination with some incipient local scientific and technological communities, supported the creation of a series of organizations responsible to promote scientific, technological and higher education activities. Some important events include the creation of a National Council of Higher Education and Scientific Research in 1935 (CONESIC for its Spanish acronym), of the Commission for the Promotion and Coordination of Scientific Research in 1942 (CICIC for its Spanish acronym), and the National Institute of Scientific Research in 1950 (INIC for its Spanish acronym).

These organizations, formed mostly by academics, scientists and public officials, were expected to contribute to the development of highly qualified human resources, the promotion of scientific research and the linking of these actions with both broader societal needs and the country's economic strategy. While the absence of an explicit and coherent S&T strategy and the limited resources committed to support S&T leads to insufficient results in all these fronts, various positive albeit scattered experiences could be observed among some of the largest higher education institutions and public research centres.

The import substitution model favoured the emergence of a local manufacturing base through a special bill for the promotion of new or necessary industrial activities, a protectionist regulatory framework, and the granting of fiscal incentives and public subsidies to local entrepreneurs. These initiatives encouraged the emergence of locally owned firms in the sector of consumer goods first, followed by the development of a sector of intermediate goods. Thus, productive capacities were developed in the cement, steel, automotive, electric, chemistry, glass, pharmaceutical and beer industries. A welcoming stance towards the establishment of foreign subsidiaries in Mexico was expected to promote the transfer of both best productive practices and advanced technological knowledge to the incipient national industry.

The Mexican government reserved public control of some strategic sectors including transport and communications, health, education, agriculture and energy. In order to support the development of these priority sectors, the government created several specialized public research centres. Some of the most important include the Mexican Institute of Social Security (1943) (IMSS for its Spanish acronym) with a mandate to work in the area of public health services; the National Institute of Cardiology (1944), the National Institute of Nutrition and the National Institute of Cancer (1946). In energy, some major events include the nationalization of the oil industry and the subsequent creation of a public enterprise, PEMEX (1938), as well as the establishment of the Mexican Petroleum Institute (1965). In the electric power industry, some relevant organizations created during this period include the Institute of Electric Research (1975) and the Salazar Nuclear Center (1964) as an immediate predecessor of the Nuclear Research Institute constituted

in 1979. In agriculture, several research centres were established including the Postgraduate College and the National Institute for Forestry, Agriculture and Farming Research (INIFAP for its Spanish acronym).

Higher education institutions received an important impulse during this period; they were central for the creation of the academic and professional forces that the industrialization process needed. Besides strengthening the UNAM and other existent universities, the National Polytechnic Institute (IPN for its Spanish acronym) saw the light in 1936. Between 1940 and 1970, 26 new state universities as well as some of the most important private universities in the country, the Monterrey Institute of Technology and Higher Education (ITESM for its Spanish acronym), the Iberoamerican University and the Mexican Autonomous Institute of Technology (ITAM for its Spanish acronym) were created.

The creation of a complex system of public and private universities and public research centres, the development of a dynamic sector of public and private domestic firms, as well as the establishment of large number of transnational firms set a minimum critical mass of S&T agents in Mexico. Unfortunately, because the emergence of all those organizations failed to respond to a well-articulated S&T policy and strategy, the complex never acquired systemic characteristics; moreover, almost from the origin the functioning of this S&T complex has been poorly articulated with broader social and economic development strategies. Rather, the development dynamics of these agents limited to the needs of an industrialization process, which tended to favour the acquisition of technologies generated elsewhere, particularly from developed countries. We can affirm that during this period, the industrial policy defined the characteristics of the agents that comprised the emergent NIS in Mexico.

The import substitution strategy tacitly assumed that the mere presence of multinational firms, and the free import of technology incorporated into capital goods, would result in positive spillover for the domestic industry, thereby creating some national capabilities to generate endogenous technological change. The results were far from the expected. The model led to the generation of certain capabilities, the simplest ones with low technological content. At the same time, however, it led to the creation of an entrepreneurial culture focused on the acquisition of technologies in the global market with scarce incentives to develop domestic technologies. In practice, this leads to a situation where the system of local universities and public research centres had little room for interaction and exchange with the productive sector. Thus, the Mexican NIS was born fragmented, without the necessary bridges and channels to allow for systemic linkages and interactions (Cimoli 2000).

3 Explicit Policies and Formal Institutions of S&T (1970–1982)

The formalization of S&T explicit policies in Mexico is closely associated with the establishment of the National Council for Science and Technology (CONACYT for its Spanish acronym) in 1970 (Casas et al. 2013; Nadal 1994;

Rocha and López 2003). The CONACYT emerged as an institution for planning and fostering scientific and technological activities in the context of a national economic policy still dominated by the import substitution model, which by 1970 showed clear signs of exhaustion.

CONACYT was the next step towards the building of an NIS in Mexico, and unlike its predecessors (CONESIC, the CICIC and the INIC), the Mexican government supported systematically CONACYT'S activities since it was created. This was the first time in Mexico's history that an S&T agency was created based on a national diagnosis on the conditions of the S&T capacities, which also informed the design of the first generation of explicit S&T policies. CONACYT also received an increased budget than its predecessors. In fact, between 1970 and 1981, the federal expenditure in S&T tripled, from 0.15 to 0.46 % of Gross Domestic Product (GDP), which significantly increased funding for higher education institutions and public research centres (Casas et al. 2013).

The main instruments operated by CONACYT were aimed at strengthening the base of human resources, via a broad program of graduate scholarships; the scientific and technological capabilities through a program to support basic research and a program for funding science and technology infrastructure. These three programs allowed the consolidation of the first academic research groups in exact, natural and social sciences, but could not develop a similar counterpart in the productive sector. Akin to other Latin American countries, the strengthening of the scientific community, partly as a result of CONACYT's policies, granted it sufficient power to decisively influence CONACYT's administration in the design, implementation and resources allocation for the next generation of S&T policies. This increased influence from the scientific community contributes to explain, to some extent, the predominance of an academic conception and the prevalence of a lineal model of S&T policies during these early stages of development of the NIS in Mexico (Nadal 1994).

While this first generation of S&T policies succeeds to some degree in creating and consolidating the first basic research group in the country, the results where much more limited in terms of connecting these research groups to the needs of domestic productive sector and contribute to developing firms' technological and innovation capabilities. Most domestic firms continued to operate based on the logic of technology transfer from abroad.

The important increase in the number of researchers in higher education and research organizations contrasts with the very slow growth in researchers more directly linked to technological and applied research activities. The S&T infrastructure increased significantly with the creation of 28 new public research centres directly managed by CONACYT and distributed throughout the country and 12 other higher education institutions, including the National Institute of Astrophysics, Optics and Electronics (INAOE, 1971), the Center for Research and Graduate Studies in Social Anthropology (CIESAS, 1973), the Southeastern Center for Ecologic Research (CIES, 1974, currently the College of the Southern Border), the Metropolitan Autonomous University (UAM, 1974), the Ecology Institute (INECOL, 1975), the Center for Applied Innovation in Competitive

Technologies (CIATEC, León, Guanajuato, 1976), the Research Center for Applied Chemistry (CIQA, Saltillo, Coahuila, 1976), the Center for Research and Technical Assistance of the State of Querétaro (CIATEQ, 1978), among others (Dutrénit et al. 2010; Casas et al. 2013).

At the end of this stage, the research community was as strong and numerous as to continue to exert a decisive influence on the direction of S&T policies, including some senior-level decision-making positions within CONACYT. The Mexican government has had to face a double challenge, first keeping the balance between respect for the autonomy of the scientific community and its political interests and second maintaining the coordination between S&T activities and the objectives of economic development. While more explicit S&T policies played a fundamental role in the configuration of the NIS during this period, the behaviour of the agents in this still emerging NIS did also have a decisive influence on the policy design, basically maintaining a science-push approach.

4 Economic Crisis, Structural Reforms and STI Policies (1982–2000)

Mexico started the 1980s amidst one of the worst economic crises in its modern economic history, which initiated in 1982. The Mexican government was obliged to radically change its development strategy with the abandoning of the import substitution model, the launch of an unprecedented process of privatization of public enterprises, the retreat of state intervention from economic activities and a comprehensive process of deregulation and liberalization. Adoption of an outward commercial orientation was formalized, first by adhering to the General Agreement on Tariffs and Trade (GATT) and later on by signing the North American Free Trade Agreement (NAFTA) at the beginning of the 1990s, the first in a long series of trade and investment agreements Mexico has entered over the last two decades. The new economic strategy effectively linked the dynamics of the Mexican economy to that of the international markets, particularly the USA.

The structural reforms had an impact on the definition and implications of S&T policies and on the functioning of the NIS. This phenomenon was not exclusive to Mexico; many Latin American countries adopted a similar development strategy, which places market mechanisms as the only institution capable of regulating the socio-economic system and defining policies. Consequently, government intervention was considered to be negative, prone to distort market mechanisms. Under these assumptions, Mexican government undertook budget cuts intended to improve the financial stance of the public sector, which extends into a drastic reduction in the federal S&T expenditures, from 0.43 to 0.25 as a share of GDP between 1981 and 1988 (SHCP 2011; CONACYT 2004, 2011).

Despite the shrinking of government intervention, during the period 1982–2000, CONACYT implemented three national S&T programs, namely the National Program for Scientific and Technological Development (1984–1988); the National

Program for the Modernization of Science and Technology (1990–1994); and the Science and Technology Program (1995–2000). In practice, these programs adopted the same objectives and strategies for the development of S&T as compared to those implemented during the 1970s. CONACYT used the same diagnosis that had informed the previous programs and policy interventions. Notwithstanding progress in the creation of minimum S&T capabilities, the structural problems and limitations of the NIS persisted. However, it can be perceived some noteworthy differences. Unlike the S&T approaches dominant throughout the seventies, during the later period, a distinction was made between policy for science and policy for technology, two areas that, though related, required different policy instruments. The new programs also placed more emphasis on the demand factors that influence the development of S&T. Last but not least, Mexican S&T authorities stressed the need to enhance efficiency in the use of the scarce resources available.

Because public intervention was justified mainly on the grounds of static market failures, technology policies assumed a marginal role. The role of the government was reduced to the correction of asymmetrical information in the productive world, or those that may arise between production and S&T activities. In this way, the government was dedicated, almost exclusively, to the regulation and control of the functioning of the legal framework and access to the educational system, but even in these fields, scope of its actions was restricted by economic and political powers of other agents.

By the mid-eighties, the NIS was comprised mostly of organizations devoted to scientific research and higher education either public or private, with regional or federal presence, and large research organizations linked to public firms—Pemex, the Federal Commission of Electricity—or to state ministries—e.g. agriculture and national institutes of health. At a more limited extent, some agents were specialized in technological development including some R&D departments within large locally owned firms, nonetheless still with little impacts in strengthen national technological capabilities. The free-market policy dogma ruled any government initiative during this period, and then, most firms were driven by the commercial trade agreements to acquire overseas technologies instead of developing them. This weakened any effort to encourage linkages with the potential national providers of scientific and technological knowledge.

In the mid-1980s, three government organizations took a leading role in the steering, promotion, and organization of S&T activities: (1) the Undersecretary of State for Scientific Research and Higher Education on behalf of the Public Education Ministry, which also coordinated CONACYT and the IPN as decentralized bodies, (2) Specific Secretaries of State at the Federal level responsible to coordinate the work of a series of organizations with a stake in S&T and that acted as decentralized organs within their respective areas of responsibility: health, energy, and agriculture, and (3) state governments that supported the operation of some S&T organizations, according to distinct conceptions of the role of S&T in local development strategies. The overall governance of the NIS was characterized by the limited coordination between different levels and instances of policy-making within the Mexican government; to a large extent, this explains the great dispersion and poor demarcation of responsibilities among the different organisms with a stake in S&T activities.

The complexity in both the structure and governance of the emerging NIS increased with the inclusion of three additional agents: the National System of Researchers program (1984); the Excellence Postgraduate Program (1991); and the creation of several councils for S&T linked to state government during the nineties; the latter as an initiative that sought the decentralization of S&T activities outside Mexico city. At the same time, CONACYT introduced a series of new programs that placed greater emphasis on applied research and technological development.

The National System of Researchers program was created to alleviate the effects of the 1982 crisis on the salaries of researchers. It is a system of pecuniary (a non-taxable scholarship) and non-pecuniary (reputation) stimuli that acknowledges research productivity. It quickly became one of the main policy instruments used to regulate and guide the development of scientific careers. The National System of Researchers program has had a decisive influence not only on both the expansion and professionalization of scientific activity, but on the incentives and actual behaviour of scientists in Mexico. Membership has become a fundamental factor to be considered as part of the evaluation of individual performance, and for the quality of graduate programs, higher education institutions and public research centres (AMC-FCCyT 2005; FCCyT 2006).

By the end of the 1980s, the formation of human resources in S&T was fostered by the scholarship program for graduate studies that privileged formation at institutions from abroad, by the National System of Researchers program and by the programs in support of basic research. The creation of the Excellence Postgraduate Program in the mid-1990s gave an additional impulse to the strategy for the development of human resources, particularly for doctoral studies. The Program aims to boost domestic infrastructure and academic capabilities.

Stimulated by the Excellence Postgraduate Program, the enrolment of students in the national postgraduate system rose more than threefold between 1992 and 2003, and the total postgraduate programmes grew from 1,686 in 1989 to 4,842 in 2003. One of the most important characteristics of the 1990s was the institutionalization of the evaluation mechanisms and the slight but constant improvement in the quality of these programs (Corona 2006). As a result, many programs started to be recognized for their excellence standards both in training human resources and in conducting scientific and technology research. The number of postgraduate programs recognized by CONACYT in the Excellence Postgraduate Program went from 414 in 1991 to 638 in 2001, and for first time, the enrolment rate in doctoral studies grew faster than the Masters.

The creation of state councils for S&T is a major achievement of the strategy to decentralization S&T activities and capabilities. In the mid-1990s, only four such councils operated in the country; by the end of the decade, the number of states that hosted an organization of suck kind reached 14. The state councils for S&T are responsible for the definition of state S&T strategies. In 1998, this strategy achieved a new milestone with the creation of the National Network of Science and Technology State Councils (REDNACECYT).

The S&T policies at a regional level were distinguished, in the first place, for the adoption of horizontal policies intended to secure the efficient functioning of

markets, and in the second place, for privileging sectors or agents that operate within the regions, with an emphasis on the promotion of private investment in S&T activities. Partly, because of the uneven distribution of S&T capabilities throughout the country, the state councils progressed at different rhythms. Some states moved forward and gradually built local technological capabilities, unfortunately, others did not manage to change their initial conditions. As a result, these different trends contributed to accentuate the differences in regional development dynamics throughout the country.

During the 1990s, the idea that industry played an important role in the development of technology and innovative capabilities was widely spread. Mexico introduced several special programs and regulations focused on promoting R&D and innovation in the productive sector. Thus, the concept of innovation emerged as a pertinent, clearly identified component to add to the S&T complex. Among the new programs, the R&D and Technological Modernization Fund (FIDETEC for its Spanish acronym), the later transformed into the Program for the Fostering of Technological Modernization in Industry (PROMTEC) and the Fund for Strengthening Science and Technology Capabilities (FORCCYTEC). The Mexican government introduced several regulatory changes intended to promote technology transfer to the industry, and the Special Program for Promoting Academia-Firm Linkages (PREAEM) and the Incubator Program for Firms based on Technology (PIEBT) were also created. The Patents and Trademarks Bill was modified in order to grant protection of intellectual property rights of firms for a longer period of time. In addition, a wide number of metrology norms and quality certifications were updated. At the macroeconomic level, the promotion of foreign direct investment and the signing of free trade agreements were expected to accelerate technological modernization of local firms.

All this illustrates the introduction of a new conceptualization of S&T policies that were the bases to build STI policies in the subsequent period. This gave rise to an entrepreneurial or business approach that still reveals a lineal model, but that is now oriented towards the requirements of the demand (demand pull). At the same time, the academic community was consolidated through the continuous and increasing integration of its members into the National System of Researchers program, which actively pressed to the already established academic conception of S&T policies.

The formal institutions that originated with the adoption of CONACYT's Organic Law and the Presidential decree that created the National System of Researchers program were, to a large extent, in charge of the S&T policies during this period and shaped the overall governance of the NIS. Even though these policies were guided by public administrations that inherited the legislation from the previous period, they were nevertheless reorganized in order to support programs, which were better aligned with the new general economic policy framework. The main characteristics of the formal institutions of S&T that emerged during the whole period 1980s–1990s were the following:

1. The deficiency of an appropriate coordination between various government dependencies related to S&T, particularly between the Public Education Ministry, where CONACYT was sectored, and different ministries that carried

out S&T activities, such as Economy, Energy and Farming, as well as the federal entities that performed some actions, with different intensity and dedication.
2. Strong concentration of policy-making and decision-making in members of few and large higher education institutions (UNAM, IPN, CINVESTAV, UAM), which concentrated a proportion of nearly three quarters of the researchers that were members of the National System of Researchers program.
3. The main instruments of S&T policies remained concentrated on the promotion of basic research, the formation of human resources at postgraduate level and the retention of researchers through scholarships. These instruments were trying to build criteria to guaranty quality of the research, addressing pertinent topics in relation to relevant national problems, or contributing to the advance of cutting age knowledge.

The public administration in charge of S&T policy-making was to large extent influenced with the economic reforms principles. For this reason, and following international trends, they were guided by pragmatic decision-making based on promoting competition, granting funds subject to results and providing support based on market mechanisms selection in order to increase production, productivity and competitiveness.

The evaluation mechanisms of S&T activities—basic research, postgraduate formation, scientific and technological infrastructure, and instruments for fostering technological development—were highly concentrated, quite neatly, in the National System of Researchers program. The emergence of peer committees for the evaluation of almost every project conceded by public administrations, which were mostly integrated by members of higher education institutions, and public research centres, together with other organizations, generated several means and procedures, both formal and informal for collaboration and cooperation.

Throughout this period, the evaluation procedures through peer committees were improved, deepened and extended to practically every allocating resources program. This represented a radical reform for some S&T public administrations that operated, from their inception, with a high degree of discretion. At the same time, the allocation of resources through the new mechanisms became more horizontal and less selective. Evaluation criteria based on productivity and quality were considered most important that those oriented towards the solution of national problems.

Although the main instruments implemented by CONACYT were mainly basic research oriented, during this period, a set of new instruments was designed to directly fostering private R&D and the building of regional systems of innovation. Despite the limited operation of these instruments, new ways of learning about their design and implementation began to be produced by the in charge areas of CONACYT, the state councils and other government bodies and ministries.

The extension of the aforementioned evaluation mechanisms did not immediately change the decision-making practices in the higher education institutions and public research centres, regarding basic research and technological development. Nevertheless, the evaluation by results and the peer committees were gradually adopted into these organizations in nearly all the associated activities: selection of research projects, graduate programs, students, courses and papers for publication.

This process, in turn, affected the authority structure in most of these organizations, separating more clearly than before the realms of academic authority from those that correspond to the administrative authority.

This tension between formal institutions and organizational structures would become an acting force when the legal changes of the 1999–2002 period took place, which introduced institutional changes conducive to the strengthening of the NIS. The Law for the Promotion of Scientific Research and Technological Development, approved by the Congress in 1999, was a first milestone in this process. This law sought to generate better conditions for encouraging academia-productive sector linkages, new funding mechanisms, such as competitive funds, and the S&T Special Program, thought it did not modify the status and location of CONACYT, who still depended on the Public Education Ministry (Cabrero et al. 2006).

5 Institutional Changes and a Greater Emphasis on Innovation (2000–2012)

The year 2000 was a breaking point in Mexico's modern political history; it marked the beginning of a new administration that, for the first time in more than 70 years, stemmed from an opposition party. The NIS governance in turn began a long series of institutional reforms, aiming at the restructuring and reorientation of the renamed STI policies, including some rather timid attempts to break-up with the traditional linear approach that had guided STI policy in Mexico since its inception. An interactive view of the STI policies began to emerge.

In 2002, a new S&T Law, which replaced the 1999 Law for the Promotion of Scientific Research and Technological Development, was approved; it was named the S&T Law. It introduced substantial changes, like a set of new organisms for the coordination and articulation between the agents of the NIS, new way of participation for stakeholders with the creation of the Scientific and Technological Advisory Forum (FCCyT), the recognition of the regionalization, and a set of policy instruments to stimulate STI activities. There were other modifications in the legal framework of STI related to the operation of CONACYT. Overall, the new S&T Law changed the government and the governance of the NIS. The new official discourse elevated S&T and notably innovation as priority sources for the country's overall development strategy. Additional modifications to this Law in 2011 included the concept of innovation to set the bases of an STI policy. All these changes contributed to generate spaces for moving from governmental policies to public policies in STI (Cabrero et al. 2006).

The 2000s was a decade of building a new governance of the NIS. The STI authorities have continued the process of experimentation and learning-by-doing, introducing, withdrawing, reshaping or deepening some instruments intended to strengthening the S&T capacities and promoting innovation. Unfortunately, commitments in terms of funding and political empowerment of CONACYT have followed pace very slowly.

Since 2012, after 12 years, the party that had left office in 2000 is back in power, and a new government is in place. The new STI authorities have the tasks to overcome the traditionally strong supply-biased approach of STI policies, an inadequate funding for STI, and the still insufficient definition of governance and coordination powers. The commitment by the new government of providing a gradual increase of the budget for STI and reaching a gross domestic expenditure on R&D (GERD) up to 1.0 % of GDP at the end of this administration in 2018, provides encouraging signals for the evolution of the NIS. Breaking inertial behaviours of agents in the Mexican NIS remains challenging but, as discussed below, some steady progress is visible.

5.1 The Reform Process and the Reorientation of the STI Policies in Mexico

In 2001, while the modifications to the legal framework were under discussion, CONACYT introduced what it intended to be a fresh mix of STI policy instruments by combining, on the one hand, some instruments carried over from previous administrations, primarily to support scientific research and the development of human resources. On the other hand, CONACYT announced a new breed of instruments specifically designed to support innovation in private firms, notably including a new fund of R&D tax credits. CONACYT followed two parallel logics of operation: Firstly, the "modernization" through the adoption of new funding mechanisms and, secondly, the closing of some older ones. The latter was important as the resources thus freed were redirected to the new instruments to support innovation (FCCyT 2006). This duality resulted in a substantial pressure on public officers, evaluation committees and on the limited resources available (FCCyT 2006).

The new strategy stirs a series of ambitious reforms related to the regulatory framework intended to reorganize the overall structure and governance of the NIS, including the use, for first time, of concepts related to or specifically referring to systems of innovation. Among the legal reforms enacted as of 2002 is noteworthy to mention the new S&T Law, new CONACYT Law (CONACYT's Organic Law), and the publication of the Special Program for S&T (PECYT) 2001–2006, as the main document guiding STI policy in Mexico.[5]

According to the S&T Law, the main collective bodies in charge of the orientation of the NIS were the General Council, whose Executive Secretary is, by law, CONACYT's General Director, and the Inter-sectoral Budget Committee, for reviewing the correspondence of the programs with the budget, which is coordinated by the Ministry of Finance and Public Credit (SHCP) and the Director of CONACYT. The Inter-sectoral Innovation Committee, coordinated by the Ministry

[5] PECYT changed its name to Special Program for STI (PECiTI) for the period 2008–2012, as innovation was more explicitly incorporated into the policies.

of Economics, aids also in these tasks. Representatives of the State Ministries and other agents integrate both committees. The National Conference on Science and Technology performs the coordination of the STI federal policies with the state policies, integrating CONACYT and the directors of the S&T state councils.

Under the assumption that Mexican government has the commitment for increasing financial resources and to adopt an integrated Federal budget for STI, the new S&T Law was regarded as a "State Policy" for STI. The consolidated budget included the resources granted to CONACYT and its associated public research system, together with all the funds allocated to STI by other ministries of the Mexican federal government. These changes could be interpreted as an effort to build a "new social contract for STI" in Mexico (Guston 2000). In some ways, STI received higher social and policy priority, hence the NIS was expected to transform significantly.

The new STI strategy was the result of learning both from past experiences in policy-making and design, and from international experiences in relation to the conduction of STI policies (FCCyT 2006). Novel features of the STI policy model included: (i) adoption of more strict quality requirements and the search for relevant R&D carried out by the public research system, which was considered as been more problem-oriented; (ii) explicit intention to promote interactivity and coordination within the STI system; (iii) commitment to a regionalization of STI capabilities across the country; (iv) explicit plans for the promotion of innovation among private firms; and (v) increasing opening for the participation of STI stakeholders and the Mexican society as a whole to better inform policy-making (PECYT 2001–2006). Concerning the participation of the stakeholders in the design of public policies in STI, the Law of S&T included the creation of the Scientific and Technological Advisory Forum to promote the expression of the STI community through three main functions: Counselling in programming (policy design and instrumentation), Counselling in budgeting (contribute to defining CONACYT's and STI budget) and Policy evaluation. This provided a space for the discussion and generation of consensus around the reforms and, eventually, any new institutional arrangements.

Reforms carry out in 2002 also granted CONACYT greater financial autonomy and independence for decision-making from the Public Education Ministry, together with top coordinating powers of the NIS—see our discussion about CONACYT's funding below. The new CONACYT Law placed the Council under direct control of the Mexican President as the head of the also newly created General Council on Scientific Research, Technological Development and Innovation. Unfortunately, the greater autonomy conferred to CONACYT was insufficient to address some of the limitations that had historically compromised the Council's capacity to govern the NIS, including its limited ability to mobilize the resources needed to achieve the ambitious goals of the new STI strategy. First, because the new bodies governing the reorganized STI system failed to operate in a recurrent basis and, second, because the dearth of financial resources hindered CONACYT's capacity to steer the operation of an increasingly complex NIS. Section 5.3 analyses with more detail the governance of the system.

5.2 The STI Budget and the New Policy Mix

The new strategic approach to STI resulted in about 60 new Funds and programs operated by CONACYT either alone or, in connection with other government organizations.[6] The Council faced different levels of involvement in this complex and heterogeneous mix, as a public policy operator, and as an agent responsible of identifying STI opportunities, including administering projects and ensuring adequate resource allocation. Broadly speaking, today CONACYT operates three types of Funds: Institutional, Sectorial and Regional. In the first case, it maintains full autonomy for goal-setting and management of the resources and structure of the Funds. By contrast, the Sectorial Funds and the Regional Funds are operated in collaboration either with other government agencies, or with state governments, respectively. The two latter funds grant CONACYT's partners almost full responsibility in the definition of the characteristics and technical operation of the Funds; the Council plays administrative roles. The underlying logic of this distribution is the improved coordination and interactivity of the public agents within Mexico's NIS.

The PECYT 2001–2006 and then the PECITI 2008–2012 aspired to GERD reaching up to 1 % of GDP. Although total GERD has grown steadily as a share of GDP since the 0.18 % in 1993, by 2012, it stood at around 0.45 %. By contrast, Brazil has sustained levels above 1 % at least since the mid-1990s (WB 2012). In 2012, the Federal Expenditures in S&T represented 0.40 % of GDP, up from the 0.30 % recorded in 1993. The share of CONACYT and its affiliated public research centres went from about 0.11 % of GDP in 2003 to 0.14 % in 2012. In fact, FCCyT (2006) documents that the really visible effect of the budgetary reform for the NIS has been the reorganization and transparency of the STI national account without new flows being injected into the system. From a long-term perspective, the figures for 2012 suggest that very little has changed since the 1980s, when both Federal Expenditure in S&T and GERD leveled below 0.5 % as a share of GDP. Without stronger commitment from the private sector, it will be difficult to reach the 1 % ratio of GERD to GDP mark.[7]

Poor financial commitment has hindered CONACYT's capacity to implement more decisive interventions to enhance incentives and to leverage private investment in S&T and, notably, innovation. The contribution of private sector to GERD grew rapidly between 1993 and 2006, from 12 % up to a historical maximum of 45 %. Since 2006, however, the share of private investment shows a downward trend reaching 38 % of the GERD in 2012. The cancellation of

[6] For a detailed analysis of the results and concrete impacts of the new programs operated by CONACYT since 2002 please refer to FCCyT (2006) and Dutrénit et al. (2010).

[7] As referred to above, the new administration, 2012–2018, has a strong commitment to gradually increase the GERD as percentage of GDP to 1 % till 2018, which can introduce a radical change in the NIS trend.

Table 1 Budget and public expenditure in science and technology 2006–2012 (millions of current dollars and percentages)

Concept	2006	2012	Growth annual rate 2006–2012 (%)[a]
Federal expenditure in science and technology	*3,052*	*4,774*	*4.9*
Agriculture, farming, rural development, fishing and food	6.3 %	5.9 %	3.6
Communications and transportation	0.4 %	0.3 %	3.6
Economy	3.3 %	2.9 %	2.8
Public education	35.7 %	31.9 %	3.0
Health and social security	6.1 %	4.0 %	−2.2
Marina	0.6 %	0.0 %	−48.8
Environment and natural resources	1.7 %	1.4 %	2.2
Attorney general of the republic	0.0 %	0.1 %	23.4
Energy	14.9 %	11.0 %	−0.3
CONACYT	30.9 %	42.2 %	10.5
Others	0.1 %	0.2 %	29.9

Sources General Report of the State of Science, Technology and Innovation; for 2012 the figure was taken from the approved general outlook for the Expenditure Budget of the Federation for the Fiscal Exercise of 2012
For the exchange rate: BANXICO (2006 = 10.9033; 2012 = 12.4272)
[a]The growth rate was calculated at constant pesos

R&D tax credit is attributed to this trend. Notwithstanding the relevant presence of multinational firms in the Mexico's productive structure and the country's efforts towards internationalization of investment and trade initiated during the mid-1980s, the share of foreign funds in total GERD is negligible, around 1 %.

Policies governing resource allocation among alternative budgetary items and execution agencies reflect the relative distribution of power across government organizations with a stake in STI. In this regard, and what seems to be a positive development, CONACYT's budgetary power within the Federal administration has recorded significant growth over the last decade; it is closing the gap relative to other instances of the federal administration, particularly the Public Education Ministry (SEP by its Spanish acronym) (see Table 1).

In 2006, the SEP enjoyed greater control of the STI budget with a share in total Federal Expenditure on S&T of 35.7 % (considerably above the share in previous decades). By contrast, the share of CONACYT was 31.9 %. By 2012, the share of SEP had fallen to 31.9 %, and that of CONACYT had reached 42.2 %. Notwithstanding the observed efforts carried out by the Mexican authorities to reorganize and redistribute the capacities to conduct STI in favour of CONACYT, still pending are more decisive efforts to improve the balance according to specific policy goals in STI activities, or between STI capacity building and actual performance of R&D and innovation projects, which imply the actual use and consolidation of existing STI capacities.

Table 2 Distribution of CONACYT's budget by main policy instrument 2003–2012

	2003	2006	2009	2012
Program or fund	%	%	%	%
Total (million dollars)	484.2	839.75	828.95	1,060.12
Scholarship program	31.0	24.7	32.0	44.6
National System of Researchers	19.3	16.0	18.7	21.9
Innovation program	–	–	14.9	14.8
R&D tax credits	9.6	43.7	–	–
Mixed funds (FOMIX)	17.3	5.2	12.1	5.7
FORDECYT	–	–	2.9	1.7
Sectorial funds	22.8	10.5	19.4	11.3
Basic science SEP-CONACYT	11.5	7.2	7.1	6.9
Health and social protection SSA/IMSS/ISSSTE-CONACYT	1.6	0.7	2.4	1.0
Energy[a]	0.4	0.0	6.7	2.6
Innovation[b]	3.9	0.7	0.6	–
Agriculture and SAGARPA-CONACYT related	2.2	0.6	1.9	0.4
Water CONAGUA-CONACYT	0.0	0.3	0.0	0.0
Airports and ASA-CONACYT related	0.2	0.1	0.2	0.1
Forestry and CONAFOR-CONACYT related	0.7	0.2	0.1	0.1
Naval sciences SEMAR-CONACYT	1.2	0.2	0.4	0.0
Other sectorial funds[c]	1.0	0.6	0.1	0.3
		2003–2006	2006–2009	2009–2012
Average growth rate for the period		20.1	−0.4	9.0

Unless otherwise stated, figures are in percentages
[a]*Includes* CONACYT-SENER-Hydrocarbons; CONACYT-Ministry of Energy-Energetic Sustainability; Sectorial Fund for Energy (CONACYT-CFE); [b]Technological Innovation Fund of CONACYT-Ministry of Economics; Sectorial Fund for Innovation (FINNOVA); [c]*Includes* CONACYT-CONAVI, CONACYT-SEMARNAT, CONACYT-INIFED, CONACYT-INMUJERES, CONACYT-SEDESOL, CONACYT-SECTUR, CONACYT-INEGI, CONACYT-SRE; Exchange rate used (pesos for a dollar): 2003 = 10.7913, 2006 = 10.9033, 2009 = 13.4983, 2012 = 12.4272
Source FCCyT based on CONACYT and Banco de Mexico

At the programmatic level, Table 2 presents some salient features of CONACYT's operation over the last decade. Between 2003 and 2012, the budget nearly tripled, from something close to 484.2 million dollars to about 1,060 million dollars equivalent in 2012. Notwithstanding this positive long-term behaviour and in line with our discussion about the erratic behaviour of public funding for STI, we observe strong fluctuations in CONACYT's funding in support of R&D and in general of innovation projects. From an average growth rate of 20.1 % in 2003–2006, at the beginning of the CONACYT reform and the need to reassign resources for the new funds and programs introduced by the new administration, funding for projects lost momentum,

particularly during 2006–2009 when resources were actually down by 0.4 %. Between 2009 and 2012, available funding grew again at an average rate of 9 %. Because the overall public expenditure in STI over the period has remained relatively constant in terms of GDP, the expansion in CONACYT's allocations has happened at the expense of available budgets for other Federal instances with a stake in STI.[8]

A look at the different funds available reveals that although innovation has gained prominence in official discourse, the budgetary allocations suggest the persistent preponderance of two interventions, namely the scholarship program and the National System of Researchers program. After a slight reduction in the combined share of these two programs between 2003 and 2006, by 2012, they had recovered their weight absorbing two-thirds of CONACYT's budget, levels similar to those of the 1990s (FCCyT 2006). Consequently, a tight third of CONACYT's budget is left to support quite a large number of other STI projects. Innovation in particular received only 14.8 % of the budget.

The significant share of the National System of Researchers and the scholarship programs within CONACYT's budget suggests that the system is kept "captive" by the overlap between two confronting policy objectives; on the one hand, the funding policy and the policy interventions targeting researchers and the pecuniary incentives in favour of specific types of research and, on the other hand, the lack of autonomy of the former policy in relation to the latter one. Beneficiaries of these instruments (students and researchers) have grown rapidly over the period of analysis, leaving very little room for driving some support to the rest of the instruments available to CONACYT. It has to be mentioned that the National System of Researchers in some way has to balance the restrictions to increase the salaries of the researchers in the public research system.

The Council has had to operate using whatever resources are left leading to strong competition for resources and severely constraining the scope of new instruments, particularly those in support of innovation. Likewise, some difficulties arose from the attempt to articulate different funding mechanisms; strategically, the Council looks for exploit complementarities among instruments. Accordingly, economic incentives to change STI agents' behaviours in relation to innovation—via resources allocation in the related instruments remain scarce or, in fact, contradictory. On the one hand, some instruments motivate researchers to increasingly carry out research with an orientation towards the solution of national problems; on the other hand, stronger incentives, both pecuniary and non-pecuniary, privilege curiosity-driven scientific research.[9] As was asserted by some authors, academic researchers face the dilemma of researching on the mainstream issues or being oriented towards national problems (Rosellón and de la Torre 2001). Indeed, most of

[8] This trend was already documented by FCCyT (2006) and Dutrénit et al. (2010).

[9] This situation has generated endless debates around the orientation and operation of the National System of Researchers for example. See for example AMC-FCCyT (2005) and Valenti et al. (2013).

the incentives seem to drive scientists to the mainstream issues (Gonzalez-Brambila and Veloso 2007).

In a way, it has been a limited progress in achievement of the goal of connecting supply and demand for knowledge through the scheme of competitive grants prevailing from the 2000s. There are still few economic incentives aimed at promoting linkages and interaction within the system. The agents have assimilated the new set of incentives according to their customary way of doing things.

CONACYT's capacity to govern the NIS has also been constrained in some way by the influence of scientific elites on decision-making, evaluation processes, goal-setting and actual conduction of STI policy. Perhaps, as a result of its past as an organization under the control of the SEP CONACYT is among the agencies "that identify themselves strongly with the scientific community", and in which monitoring is organized by peer-review processes that are dominated by the community of scientists, which also applies for the funding. In such a configuration, even if governments transfer the resources, in practice, scientists remain "in control" (Van der Meulen 2003: 325). The control of research agenda and subsequent resources allocation by the scientific community is not necessarily problematic as long as peer-review processes grant "legitimacy" to both conduction and outcomes of decision-making processes. As recent evaluations to programs administrated by CONACYT indicate (Valenti et al. 2013), problems arise when the composition and criteria of evaluation committees poorly reflect the changing objectives and orientation of STI policy, when the pool of experts to draw from is limited, or when the community has already some vested interest built-in for the preservation of certain practices or organizations, even if the continuous growth of such practices and/or organizations is potentially detrimental for the NIS as a whole. What is striking is that in a context of low general funding for STI activities, the scientific community does neither receive enough resources.

The adoption of innovation as a priority for STI policy has led CONACYT to enter a process of experimentation and learning via the adoption, review and closure of different programs and funding mechanisms (FCCyT 2006; Dutrénit et al. 2010). After the initial success of the new R&D tax credits, which by 2006 was equivalent to 43.7 % of CONACYT's budget, some concerns arose about the accuracy and transparency in the management of the instrument. A new mechanism for the promotion of incentives to innovation is now in place, named the Program of Stimulus for Innovation (PEI, as it's known by its Spanish acronym). This program is targeted to foster firm's investment in R&D and other innovation activities through direct support. The program operates under three different modalities: INNOVAPYME (for small and medium enterprises), PROINNOVA (for new and potential technologies) and INNOVATEC (for large firms).

Regarding regionalization of STI capacities, in addition to the Regional Funds, in 2009, CONACYT launched a new mechanism, the Fund for the Regional Fostering of Science, Technology and Innovation (FORDECyT). It focuses on solving regional problems by fostering scientific, technological and high-impact innovative solutions, as well as forming specialized human resources on STI. We still do not know how much consistency CONACYT will be able to maintain in

terms of sustained financial commitments to both of these instruments. It will depend on the increase of the Federal Expenditure in S&T and the matching funds committed by the state governments.

5.3 Problems in the Governance of the System

Throughout this period, a new perspective of STI policy emerged. This policy changed the approach from one that considered the government view to other in which regions, industrial sectors and all the NIS's agents took a major role; in other words, from policy-makers and individual beneficiaries to a new approach in which multi-sectorial networks, multi-levels and vertical and horizontal innovations network are central. In the processes of public policy building, several actors with different interest, values and perspective converge (Puchet et al. 2013). This new approach sought to avoid the development of one dominant player, but rather what Kuhlmann (1999) calls strategic intelligence, that is, a vision built from multiple perspectives of competing actors that elevated the rationality of negotiations.

In the configuration of the Mexican NIS and regarding the functioning and operation of the collegiate bodies and authority instances related to the design, implementation and evaluation of the STI policies, four instances excel: the General Council of Scientific Research, Technological Development and Innovation (hereinafter General Council) and its Executive Secretariat; the Intersectoral Budget Committee and the Inter-sectorial Committee for Innovation; the National Conference of S&T, and the Board of Directors of CONACYT. The General Council is the maximum organ of the NIS; it is led by the Mexican President, the General Director of CONACYT is its executive secretary, and secretaries from nine ministries, academia and the private sector participate as well. It establishes, approves and defines the national policies of STI, the PECiTI, and the priorities and criteria for the allocation of the federal public expenditure, among other functions.

The formal institutions of S&T that predominated during the nineties faced the changes in the legal framework introduced by the S&T Law of 2002. This period has been one of learning and building a new governance of the system. It could be observed a slow understanding of the scope of the judicial regulations by the Federal Executive Branch, dissimilar visions of the agents that participate in these instances, and a lack of defining clearer responsibilities of the Federal Ministries responsibilities regarding STI activities (Puchet et al. 2013).

Regarding the slow understanding of the scope of the judicial regulations, the General Council, as an organ that guides a state policy in STI, has only met sporadically, and due this, it has been unable of fulfilled its task. This has leaved the Inter-sectoral Budget Committee as the effective decision-taker and policy-maker through its involvement in designing and negotiating the budget for STI. This Committee serves as space for mediation and opinion exchange among the different agent of the public sector regarding the congruence of the programs and

budgets and, above all, the contribution of the budgets of each sector in the total federal expenditure in STI. Officials with the legal rank in programing and budgeting do not always participate in the meetings of this Committee, which makes it difficult to take the required decision. In addition, the National Conference, which connects federal and regional stakeholders, is still learning how to integrate and operate the required technical working groups. Therefore, a legally elaborated institutional design, set in motion with broad political support and participation, integrality and multiple checks and balances, has not finished its building process (Puchet et al. 2013).

The horizontal decision-making processes, where both individual agents and voluntarily organizations participate and articulate, are subject to very diverse rules that stem from the organizations themselves and from a set of laws and regulations. These intersect and overlap with the internal organizational rules, the informal rules which arisen from the interaction of agents and organizations, and the codes of conduct and established practices of the participants. Recent studies show that these processes have generated instances and spaces of concerted actions between agents and organizations of a various kinds. Prominent among them are the territorially based clusters centred on productive activities that incorporate frontier technologies on the automotive, electronics, aeronautics and computer industries, among others (Dussel et al. 2003; Casalet 2013). There are also experiences of linkage between universities or research centres and farmers (Rivera et al. 2011; Vera-Cruz et al. 2011; Dutrénit et al. 2010) or with rural or indigenous communities (Argueta Villamar et al. 2012). These actions are carried out through several organizational forms like offices of knowledge transfer, specific agreements or the permanent collaboration between members of different organizations.

Many of these concerted actions between STI agents are made following the guidelines of programs and plans of different organizations, including the governments at various levels. Their main characteristic is that they are inspired and encouraged by a paradigm guided by the terms “connecting agents”, “linking organizations of different ends and origins” and “knowledge transfer”. This code gives meaning to their actions and makes them vital and essential parts of the social and cultural processes of governance of the system.

What attributes in terms of efficiency, effectiveness and capacity to obtain their ends do these processes have? The available studies emphasize the assessment of the objectives reached by each process. That is, they are effective processes capable of generating ends for their participants, but it is complicated to know how effective they are from the perspective of evaluation. Allegedly, in the measure that many of these processes are sustained during long periods of time, they have important degrees of efficiency. However, this makes it difficult to assess contributions to governance made by all these decentralized and disperse processes in general spaces. Some are autonomous, others are induced by stimuli or incentives, some are based on plans and programs of certain organizations, or in more or less explicit agreements among themselves. There are some that are performed with internal funding or through the use of funds that come from the setting in motion of different policies.

Thus, we have a landscape where the exercise of authority in order to put in practice STI activities is diverse in its constitution, in the rules to which it is subject, and in the comprehension that the different participants have about it.

The main instance for the participation of STI communities is the Science and technology Advisory Forum (Casas et al. 2013). The Forum has promoted the opinions of its constituents within the processes of formulation and implementation of programs and policies. It has also recognized, in many cases, the challenges of the governance processes that have been developed throughout the NIS.

Undoubtedly, there are novel processes of decentralized governance in Mexico, mechanisms and forms of agents' participation at different levels are observed, and different channels have been established for facilitating the feedback between STI communities and policy-makers in STI. There are programming and budgeting activities that comprise stable government processes, although they are probably too much like a routine and, in many cases, they still lack the feedback of an evaluation. Beyond the advances, there are still some flaws in the functioning of the main federal bodies of decision-making in STI.

Transforming the observed governance of the new networks and agreements in many areas of the NIS in a capacity that guides the system as a whole requires that the instances of the government provide everyday certainty and stability to the agents. The extension and depth of the decentralization processes, including governance, will become an attribute of the system when the government of the STI could stabilize and institutionalize its operations.

6 Conclusions

This document has illustrated how public policy intervention has contributed to the building and nurturing of the NIS in Mexico and how this system has given feedback to the design, tailoring and implementation of STI policies. After a long period of institutional building, the Mexican case illustrates that the institutional framework has set some constrictions to the unfolding of public intervention. In this sense, the evidence illustrate that the interplay between STI policy, institutional settings and the NIS is crucial in understanding how the NIS evolves.

Four main stages in the design and implementation of STI policies in Mexico have been identified. The long period from the early 1930s up to the 1970s was characterized by the absence of an explicit and institutionalized STI policy; and yet, this was a period when important decisions were made, particularly for the creation of a series of organizations, which were to play major roles in the construction of STI capacities. In this period, the roots for the overall functioning and governance of the NIS in subsequent years can be found. During this period, some structures of the NIS emerged, but overall, the import substitution model embedded some critical characteristics and behaviours in the actors that did not help to build domestic technological capabilities. These features persisted during the next stages and were difficult to change. Second stage roughly running

between 1970, year of the creation of CONACYT, up to the early 1980, was characterized by the predominance of linear approaches to S&T, with a strong centralization of decision-making and resource allocation, and a very poor interactivity and coordination among the different agents and policies shaping the then emerging NIS. In effect, the governance of the system tended to privilege investments in science, which was effectively superposed above investment on technological developments. During this period, innovation was seldom present in both political discourse and actual practice. The third period was a transition; it was a period of crisis and structural reforms, where public intervention was only justified upon static market failures. STI policies acquired a marginal role, which impacted the definition of policies and of the NIS itself. Even so, three additional actors emerged: the National System of Researchers Program, The Excellence Postgraduate Program and several state Councils for supporting S&T. The governance of the NIS was characterized by a limited coordination between the different levels and instances of government.

Finally, a fourth period started by 2000, when STI authorities have sought three key objectives. First, enhanced recognition of innovation as an activity in its own right and value, thus deserving concrete interventions leading to more allocation of resources. Second, Mexican STI authorities, particularly CONACYT, have attempted to improve interactivity, coordination and collaboration among the different agents that shape Mexico's NIS by structuring a series of ad hoc interventions as part of the overall policy mix. Third, conscious efforts were made to improve governance of the NIS via the continuous reform of the institutional environment around STI, and the adoption of instruments specifically intended to improve decentralization and regionalization of STI capacities and activities throughout the country. The NIS moved forward throughout the decade, but unfortunately, the pace was slower than it was required.

The new conception of STI policy, termed here «interactive conception», has coexisted with other ideas, particularly the academic one, rooted on the main institutions of higher education that maintain a high degree of decision power. The evidence from the allocation of resources reveals the persistence of lineal approaches both in policy-makers as in the STI community. Accordingly, and as could be expected from the literature (van der Meulen 2003), CONACYT's role in governing the NIS has become increasingly complex. It has to address governmental priorities, stakeholders' requirements and social needs, induce structural changes in the research base by means of reforming public research centres, introduce new funding schemes, promote the revision of research agendas, ensure strict peer-review based on competition and so on. Those increased responsibilities have been only timidly funded with the political power required to induce appropriate incentives to alter the agents' behaviours.

CONACYT is slowly sorting out some historical imbalances, in terms of budget and decision-making capacities, relative to other government instances with a stake in STI. Somewhat more difficult to tackle is the persistent influence from the federal instances in policy-making and actual policy intervention in relation to regional participation, and the difficulties to build a governance with a

broader participation of the stakeholders and society and based on a combination of top–down and bottom–up approaches.

Mexico's STI strategy continues to lean heavily towards the creation of basic research capacities as it seeks to catch up with distant world leaders in the field of STI. The strategy is not without limitations, sustaining a growth dynamic requires, by necessity, quantum budgetary increases from both public and private sources. Clearly, however, investment needs to accompany strategies which are flexible enough to identify and adjust to the needs of the changing NIS. The agents in the system face the challenge of continuously and objectively assessing the pertinence and contribution of the myriad of programs being administered by STI authorities. Some of those have been quite successful in the past, but, in the current circumstances, such success can potentially introduce considerable limitations for the continued expansion of the NIS. For instance, the pertinence of programs such as the National System of Researchers and the scholarship program is undeniable, a wealth of evidence documents the significant gaps that Mexico records relative to other countries in this area. Arguably, however, major changes in the strategy supporting the development of human resources are needed. Continuous expansion of the National System of Researchers and the scholarship program takes the lion's share of CONACYT's funding, severely constraining investments to promote R&D and other innovation projects. As Castaños-Lomnitz (2004) and Santiago (2010) document, whereas issues of brain drain remain of concern, the dynamics of labour markets for highly qualified human resources in STI in Mexico remain poorly understood.

The government and the governance of the NIS have evolved in the last decade, particularly since the S&T Law enacted in 2002. Nowadays, Mexico has a modern institutional framework, but it requires the acceleration of the learning process in order to improve the government and generate beneficial effects on governance. Nearly 70 STI organizations came together in the elaboration of a document entitled "Towards a national agenda in STI", in which a proposal for the creation of a Ministry of STI was included. Undoubtedly, the first step is the compliance with the legal regulations, the re-enforcement of the operation of the system, and the transition towards improved legal and regulatory forms, more adequate to the principles of full participation of the actors, compliance with the legal norms and coordination of the system (Puchet et al. 2013). The new administration was not very keen with this proposal, but it has manifested its disposition for the compliance with the legal system.

A constant in STI policy in Mexico throughout its recent history has been the reduced federal expenditure in S&T and GERD as a percentage of GDP. Moreover, recurrent fluctuations in public expenditure in the sector reflect the lack of a well-defined funding strategy by the government, and together a failure to subsequently induce matching investment from the private sector. This reveals that the different administrations, policy-makers and society do not perceive STI as having an important impact on economic development and social well-being. Probably for the same reason, this also reveals in some way the low negotiation power of the STI community leaders.

After nearly 14 years of continuous reform, Mexico's NIS has experienced a considerable expansion and an increasing complexity and heterogeneity of the agents shaping it. Albeit productive, the research base remains small relative to both the relative weight of Mexico in the world's economy and to international standards. The country continues to suffer from limited research infrastructure, a small pool of very productive researchers, a volume of scientific output that hardly reflects the relative importance of the Mexican economy, extremely low investment in R&D, particularly by the private sector and a strong dependence on public funding for STI. More importantly, drawing connections between domestic STI capacities and the generation, dissemination and use of knowledge according to some well-identified development priorities remains problematic. Even though it is broadly recognized that transversality may be a positive feature of STI policy, as it may generate synergies between different agents of the NIS (Kuhlmann 2001; Georghiou 2001; Cooke 2011), difficulties to coordinate the ministries with CONACYT militate against the possibility of taking advantage of this feature.

These are the challenges for the new administration starting in December 2012. By now, the government commitment to increase the budget and reach a target of expenditure as percentage of the GDP of 1 % provides a good signal for the future evolution of the NIS. The foundations of the NIS were already built; therefore, it seems that the system is ready for absorbing fresh resources and produce efficient results.

References

AMC-FCCyT (2005) Una reflexión sobre el Sistema Nacional de Investigadores a 20 años de su creación. Academia Mexicana de Ciencias and Foro Consultivo Científico y Tecnológico, Mexico

Argueta A et al (2012) Conocimiento Tradicional, Innovación y Reapropiación Social. Siglo XXI, Mexico

Arocena R, Sutz J (2012) Research and innovation policies for social inclusion: is there an emerging pattern? In: Lastres HMM et al (eds) A nova geração de políticas de desenvolvimento produtivo—sustentabilidade social e ambiental. CNI, BNDES, BID, Brasilia, p 101–113

Azzazzy H (2011) Revolutionizing Egypt's science: A new day for Egyptian science? Science 333(6040):278-284

Cabrero E et al (eds) (2006) El diseño institucional de la política de ciencia y tecnología en México. UNAM-IIJ, CIDE, Mexico

Casalet M (2006) Las nuevas tendencias en la organización y financiamiento de la investigación. Presented at the International Seminar on Globalization, Knowledge and Growth at UNAM, Mexico, 2006

Casalet M (ed) (2013) La industria aeroespacial. Complejidad productiva e institucional. FLACSO, Mexico

Casas R et al (2013) Construyendo el diálogo entre los actores del sistema de ciencia, tecnología e innovación. FCCyT, Mexico

Castaños-Lomnitz H (2004) La migración de talentos en México. UNAM-IIEc, Mexico

Cimoli M (2000) Developing Innovation Systems: Mexico in the Global Context. Pinter, London

CONACYT (2004) Informe General del Estado de la Ciencia y la Tecnología. CONACYT, Mexico

CONACYT (2011) Informe General del Estado de la Ciencia y la Tecnología. CONACYT, Mexico
Cooke P (2011) Transversality and regional innovation platforms. In: Cooke P et al (eds) The Handbook of Regional Innovation & Growth. Edward Elgar, Cheltenham
Corona JM (2006) Human capital formation: the role of Science and Technology Policy. A case study in the Mexican Biotechnology Sector. Dissertation, University of Manchester
Cozzens S, Sutz J (2012) Innovation in Informal Settings: A Research Agenda. http://www.idrc.ca/EN/Lists/Publications/Attachments/1130/IID%20Framework%20July%2029.pdf
Dussel E et al (eds) (2003) La industria electrónica en Jalisco y México. Condiciones y propuestas de política económica. UdG, Mexico
Dutrénit G (2012) Innovación para el desarrollo en América Latina: dónde estamos respecto a las masas críticas de capacidades. In: Álvarez I, Botella C (eds) Innovación y Desarrollo: Retos para una Sociedad Global. Fundación Carolina/Siglo XXI, Madrid, p 173–202
Dutrénit G et al (2010) El sistema nacional de innovación mexicano: estructuras, políticas, desempeño y desafíos. UAM/Textual, Mexico and Montevideo, p 446
Edquist C (ed) (1997) Systems of Innovation: Technologies, Institutions and Organisations. Pinter, London
Edquist C, Hommen L (2006) Comparing National Systems of Innovation in Asia and Europe: Growth, Globalisation, Change, and Policy
Foro Consultivo Científico y Tecnológico (2006) Bases para una Política de Estado en Ciencia y Tecnología e Innovación en México. FCCyT, Mexico, p 300
Freeman C (1987) Technology, policy and economic performance: lessons from Japan. Pinter, London
Gault F (2010) Innovation Strategies for a Global Economy. Edward Elgar, Cheltenham, p 232
Georghiou L (2001) Evolving frameworks for European collaboration in research and technology. Res Policy 30(6):891–903
Gonzalez-Brambila C et al (2007) The Determinants of Research Productivity: A Study of Mexican Researchers. http://www.repository.cmu.edu/cgi/viewcontent.cgi?article=1132&context=epp
Guston DH (2000) Retiring the social contract for science. Issues Sci Technol 16
Hawkins R (2012) Looking at Innovation from a Uniquely Canadian Perspective: The Case for a New Alliance of Practice, Policy and Scholarship. http://www.issp.uottawa.ca/eng/pdf/HawkinsPaper.pdf
Hodgson GM (2011) Evolutionary and Institutional Economics as the New Mainstream? In: Aboites J, Corona JM (eds) Economía de la innovación y desarrollo. UAM–X/Siglo XXI, Mexico, p 104–119
Huffman, Just (2000) Setting Efficient Incentives for Agriculture Research: Lessons from Principal-Agent Theory. Am J Agr Econ 82(4):828–841
Jaso M, Corona JM (2013) Las Políticas de Ciencia, Tecnología e Innovación 2001-2012: Avances, problemas y desafíos. UAM, Mexico
Laffont JJ, Martimort D (2002) The theory of incentives. Princeton University Press, Princeton
Lundvall B-A (ed) (1992) National Systems of Innovation. Towards a Theory of Innovation and Interactive Learning. Pinter, London
Lundvall B-A (2003), National Innovation System: History and Theory, Paper presented at the NSTDA-JICA seminar on innovation systems in Asian Economies, Bangkok, 4-5 September 2003.
Kraemer-Mbula E, Wamae W (2010) Innovation and the Development Agenda. OECD, Paris, p 152
Kuhlmann S et al (1999) Improving Distributed Intelligence in Complex Innovation Systems. Final Report of the Advanced Science & Technology Policy Planning Network (ASTPP). Fraunhofer Society/ISI, Karlsruhe
Kuhlmann S (2001) Future governance of innovation policy in Europe: three scenarios. Res Policy 30(6):953–976
Metcalfe S (1994) Evolutionary economics and public policy. Econ J 104(425):931–944
Nadal A (1994) Harnessing the politics of science and technology policy in Mexico. In: Bastos MI, Cooper C (eds) Politics of technology in Latin America. UNU/Intech, Maastricht, p 109–153

Nelson R, Rosenberg N (1993) Technical Innovation and National Systems. in: Nelson R (ed) National Innovation Systems: a Comparative Study. Oxford University Press, New York, p 3–21
OECD (2010) The OECD Innovation Strategy: Getting a Head Start on Tomorrow. p 225
OECD (2012) Innovation and inclusive development: Discussion report. Revised version February 2013. p 67
Puchet M, Ruiz P (2002) Nuevas leyes de ciencia y tecnología y orgánica del CONACYT. Buenos propósitos, cambios institucionales y concentración presidencial de las decisiones. UNAM/Porrúa, Mexico
Puchet M et al (2013) Gobierno y gobernanza de las actividades de CTI. FCCyT, Mexico
Rivera R et al (2011) Do linkages between commercial farmers and academic researchers influence researcher productivity? The Mexican case. In: Aboites J, Corona JM (eds) Economía de la innovación y desarrollo. UAM–X/Siglo XXI, Mexico, p 216–235
Rocha A, López R (2003) Política en ciencia y tecnología en México: un análisis retrospectivo. In: Aboites J, Dutrénit G: Innovación, aprendizaje y creación de capacidades tecnológicas. UAM, Mexico
Rosellón J, de la Torre B (2001) El modelo principal agente en el análisis de la Política científica de países en desarrollo. In: Abila A et al (eds) Ciencia económica y economía de la ciencia. FCE, Madrid, p 235–266
Santiago F (2010) Human Resource Management Practices and Learning for Innovation in Developing Countries: Pharmaceutical Firms in Mexico. UNU-MERIT, Maastricht. http://arno.unimaas.nl/show.cgi?fid=21174
Scerri M, Lastres H (eds) (2013) The role of the State. IDRC, Ottawa
Secretaría de Hacienda y Crédito Público (2011) Cuenta de la Hacienda Pública Federal, 2002–2011. SHCP, Mexico
Smits R et al (eds) (2010) The Theory and Practice of Innovation Policy. An International Research Handbook. Edward Elgar, Cheltenham
Sotarauta M, Srinivas S (2005) Co-evolutionary policy process: Understanding innovative economies and future resilience. Futures 38:312–336
STEPS (2010) Innovation, Sustainability, Development: A New Manifesto. STEPS (Social, Technological and Environmental Pathways to Sustainability) Centre, Brighton, p 24
The Economist (2012) Mexico's moment. http://www.economist.com/news/21566314-enrique-pe%C3%B1a-nieto-mexicos-newlyelected-president-sets-out-his-priorities-mexicos-moment. Accessed 24 May 2013
UNESCO (2010) Science Report 2010. UNESCO, Paris
Valdés F (2008) Gobernanza e instituciones. Propuestas para una agenda de investigación. Perfiles latinoamericanos 31:95–119
Valenti G et al (2013) Formación, Investigación y Transferencia de conocimientos. FCCyT, Mexico
Van der Meulen B (2003) New roles and strategies of a research council: intermediation of the principal-agent relationship. Sci Publ Policy 30(5):323–336
Vera-Cruz A et al (2011) Financiamiento de la investigación y la innovación mediante fondos competidos: balance del caso de la agricultura mexicana. In: Aboites J, Corona JM (eds) Economía de la innovación y desarrollo. UAM-X/Siglo XXI, Mexico, pp 192–215

Websites

WB [World Bank] (2012) World Development Indicators: Research and development expenditure (% of GDP) http://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS. Accessed 25 May 2013

Evolution of the Public Institutions of Science, Technology, and Innovation in Chile: 1990–2012

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Abstract This work presents a description of the evolution of Science and Technology (S&T) Policies in Chile. We have differentiated three periods: before the creation of the National Innovation Council for Competitiveness (CNIC, according to its Spanish acronym) and the establishment of royalties (specific taxes) up to the extraction of mineral resources, from the creation of both institutions up to the end of President Bachelet's government, and the years under the leadership of President Piñera. We will study the second- and third-mentioned periods in greater detail, as it was during these years that the present institutional framework began to take shape. This analysis will make clear that there are different alternatives when constructing public innovation support systems and that each has its associated risks and advantages.

1 Introduction

Regarding productive development, there is wide consensus concerning the importance of knowledge and innovation. Effectively, evidence shows that differences observed between countries concerning income level and growth rate per capita are more closely associated with the total factor productivity (TFP) than with their

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accumulation[1] and that innovation is a powerful instrument for the promotion of efficacy for the application of production factors.

The above statement is especially true in Chile, a county where a decreasing trend in TFP is observed, and where efforts must be made to move from a production structure concentrated on the production and export of raw materials to one based on knowledge and innovation, permitting an increase in the added value of these commodities.

The theoretical and empirical evidence also suggests that in the absence of public support, economies assign scarce resources to innovation. Given the problems of appropriating benefits associated with new knowledge, and the elevated level of uncertainty inherent in activities related to research and development (R&D), in an economy guided exclusively by trends in the market, private innovation efforts—as a result of low remuneration—will be lower than socially desirable. R&D generally present higher social returns than private activities, and the latter can sometimes even be negative.[2]

Furthermore, the process of generating knowledge involves a multitude of agents, those guided by market incentives (companies), or by other institutions acting under the influence of alternative motivations (for example universities, public research centers), and problems of coordination often arise between such agents. It is effectively often difficult (if not impossible) to establish full contract, and other opportunities may come with specific assets and high transaction costs. Problems of coordination become more serious when the tacit component of knowledge becomes relevant (in such cases, the transmission of this knowledge cannot be only in written form, but necessarily involves human interaction). This indicates the need to systemically appraise innovation.

To summarize, the existence of faults in the market is discouraging to the innovative effort of private companies and makes cooperation difficult in the context of R&D projects. The presence of these flaws explains why the innovation effort does not "spontaneously" reach a socially optimal level, making it an undeniable priority that public intervention should aid its economy.

However, it is not only State-granted incentives for potential innovators that matter, but also the search to design a support system where actors who participate in the innovation process can be efficiently incorporated. There is no solution to this problem; several countries have proposed different strategies. Chile has created and consolidated an institutional framework for innovation support, which has taken into account experiences from the most successful countries, as well as the advantages and disadvantages of different models in the context of a country still on the way toward development. In the following section, we refer to these models and to the evolution of the Chilean National Innovation System (SNI by its Spanish acronym).

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[1] Klenow and Rodríguez-Clare (1997), Hall and Jones (1999), Fagerberg and Verspagen (2003), Easterly and Levine (2002).

[2] Benavente et al. (2005), Lederman and Maloney (2003), Romer (1990).

2 Public Support Systems For STI: The Structure Matters

SNI refers to the group of agencies and rules associated with the creation of knowledge and its future application in production. According to this definition, technical progress is the result of the interaction between the various agents which generate, adapt, and improve new technologies.[3] The institutional structure of the SNI determines the way in which the different actors interact and organize, and therefore affect the dynamics of the innovation process.

In the SNI, given existing flaws in the market and the coordination problems mentioned in the above section, the public sector plays a fundamental role. However, this action is not free of challenges. Evident trade-offs exist between control, coordination, efficiency, and impact as well as the existence of at least three sources of risk, associated with public intervention in this area:

- Dynamic inconsistency: The difficulty the public authorities face in persevering with actions whose benefits are manifested outside of their mandate period. In order to confront this problem, there must be a space for discussion regarding the policies which promote innovation and their related activities. It must be independent from the political cycle and comprehend appropriate incentives for the definition, implementation, and evaluation of a long-term strategy.
- Problem of agency: Derives from the asymmetry of information that exists between the hierarchical relationships within the SNI. To face this risk, we must separate the roles of design and execution, and design control mechanisms which diminish the information gap and align the apparent incentives at different levels of the system.
- Risk of capture: This refers to the possibility of the State intervening in response to the demand of interest groups. In the case of innovation, a given group may extract specific benefits from certain programs, resulting in the State financing activities where the benefits can easily be appropriated by the private perspective; public support would then be redundant. This situation is exacerbated when the public innovation support apparatus is fragmented and works on a basis of watertight compartments: In these cases, it is the enforcers of policies who capture the society's resources, as they prefer to maintain the status quo rather than open up to competition based on performance. To avoid these problems, we must clearly define the space of intervention, separate the strategic level of those that are most operational, and implement appropriate control mechanisms.

Below, we present the taxonomy of public systems for innovation support, and we will discuss some of the advantages and disadvantages, in terms of the relative capacity to face each one of these risks. According to this taxonomy, proposed by Tekes (2002), there are three ways in which public support for innovation

[3] Freeman (1982), Nelson (1993) and Lundvall (1985).

can be structured, namely dominant player model, pillarized model, and labor division model. It is important to mention that the relative advantages of each of these models depend on the contextual factors of each country; different countries have adapted the structure to their systems, in order to better define the *objectives, clearly establish the division of responsibilities*, improve coordination, and increase impact and transparency, thus creating different institutional structures according to their own realities.

The first institutional structure corresponds to the *Dominant Player Model*, which may have dominant actors at the level of politics and/or intermediaries. At the strategic level, the policies of economic and commercial development are incorporated with those relating to science and technology. This structure significantly decreases the problems of fragmentation, and therefore coordination failures, but can also be very complex; it lacks specificity and can therefore result in the sacrifice of gains in efficiency. Lastly, in a structure such as this one, the problem of agency can be severe if the appropriate control mechanisms are not in place.

The opposite extreme is the so-called *Pillarized Model*, where different organizations specialize in specific areas of innovation and design and implement policies through their own agencies. Thus, specialization is significant, but so is the system's fragmentation, allowing for the exploitation of synergies and economies of scale and scope; contrarily, this structure tends to exhibit duplicity of activities and objectives. Lastly, since this model does not have a higher instance with the appropriate control mechanisms, it is expected that risk of capture will be considerable.

Finally, we should refer to the *Labor Division Model*, which privileges the existence of parallel subsystems (generally headed by powerful ministers) which support different stages and/or scopes of the innovation process; for example, one organism may be in charge of higher education and the promotion of basic research, while a different one is in charge of the promotion of business innovation and entrepreneurship. This institutional arrangement indicates a tendency toward consolidation in Chile that favors a systematic view of innovation and clearly establishes responsibilities, although it can result in coordination problems and duplicated efforts, and may not permit an adequate response to risks of capture and problems of agency.

Taking into account the advantages and disadvantages of each alternative, many countries have oscillated between these different models. For example, due to the coordination and fragmentation problems that arise with the more extreme models, some countries have finally opted for a labor division model, also making it possible to incorporate a geographically decentralized strategic orientation, so that intermediary agencies are closer to the executive level, and can therefore better identify the specific needs of each "client."

However, it is important to consider that none of these models are free from the above-mentioned faults, and correct control mechanisms must therefore be incorporated, as well as defining the function of each organism clearly, and periodically evaluating the system's performance.

3 Evolution of the Chilean SNI

3.1 From 1990 to 2005

In the early 1990s, it was evident that the economy's productivity needed to be stimulated; therefore, with support from the Inter-American Development Bank (IDB), the government began to develop a national-level innovation strategy (Benavente et al. 2007).

During that decade, programs were designed in order to provide incentive for R&D activities in businesses, providing competitive funding and innovation support programs which did not privilege specific production areas, but instead had a more neutral approach, thus focusing the role of the market and the role of demand.

At the beginning of the following decade, there was a shift toward a more mixed approach; public support was focused on those areas and technologies which applied cross-wise to all production sectors and had the potential to improve production and competitiveness in Chilean companies.[4] However, simultaneously, there were prospective initiatives which, even though they did not prosper very much, created a "first taste" for picking the winners, promoting a strategy based on supporting certain clusters with production potential.

Toward 2004, the Chilean's SNI structure was of the type of Division of Labors: At an intermediate level, the National Commission for Scientific and Technological Research (CONICYT according to its Spanish acronym) and the Chilean Economic Development Agency (CORFO according to its Spanish acronym) stand out. The first of these implemented policies oriented toward scientific research and the formation of specialized human resources, while CORFO was in charge of support programs for innovation and entrepreneurship. The Technological Development and Innovation Program (PDIT by its Spanish acronym) operated at a higher level. Based on the Ministry of the Economy, it is in charge of coordinating the implementation of policies. However, in practice, the influence of the higher level on the rest of the system was limited; actions were still defined in a relatively decentralized manner, by many agencies, which in turn depended on many ministries. This did not permit the exploitation of economies of scale and scope and generated confusion at the level of objectives and clients. This resulted in problems of coordination and fragmentation which became inefficiencies.[5] Furthermore, the institutional framework permitted taking control of politics

[4] Emphasis was placed on the sectors considered to be priority due to the increase in competitiveness of companies: biotechnology, clean production, and quality promotion and information technologies. At the same time, initiatives were implemented in order to carry out prospective studies in the areas considered to be priority and with the potential to improve competitiveness in the corresponding sectors.

[5] OECD (2007).

which incorporated a selective view when defining policies. This institutional framework, given its fragmentation, also appeared too weak to administrate not only instruments but programs as well, with an ever-increasing scale of funding.

Expressed simply, in the middle of the last decade, the Chilean SNI lacked an explicit, conscientious, and long-term strategy and also lacked a formal public institutional framework that was able to coordinate and evaluate the efforts made.

3.2 Period 2005–March 2010

3.2.1 CNIC, Mining Royalties, and the FIC

During this period, a series of initiatives were implemented which broke the trend of this institutionalism and policies of support for innovation. The first of these initiatives, implemented in 2005, was set in the area of financing for innovation: A royalty was established for mining activities, and the resulting higher tax revenue was transferred to the Innovation Fund for Competitiveness (FIC according to its Spanish acronym), legally created in the same year. Likewise, an Innovation Board was created, with the purpose of suggesting priorities for the use of FIC resources, which would be channeled through the existing intermediary agencies. The president of this Board was Edgardo Boeninger (1925–2009), who was an important figure in the political transition toward democracy. This board generated consensus between all the public sectors, and its members were persons from the academic, business, and scientific worlds, as well as Ministers of Economy, Treasury, and Education.

The following year, this board was ratified as a permanent consulting body of the presidency and was then named the National Innovation Council for Competitiveness (CNIC). It was first presided by the Ministry of Treasury of the previous administration, and its mission, as well as advising on the assignment of resources, was to define a 12-year National Innovation Strategy (the time period defined for the strategy and the fact that the direction was in the hands of a person not related to the government administration, permitted its dissociation from the political cycle). In order for the CNIC to achieve its objectives, the Executive Secretariat was created, with its own budget guaranteed by law.

By mid-2007, the Inter-Ministerial Committee on Innovation was created, with the aim of ensuring the system's governability, differentiating between the role of consultant and that related to the execution and coordination of CTI policy. Thus, it was the role of the CNIC to propose a strategy and monitor the compliance of its objectives, while the Inter-Ministerial Committee would implement policies and facilitate coordination between the executing institutions, as these depend precisely on the different ministries.

The last government administration known as the Concert of Parties for Democracy (political alliance which governed from 1989 to 2009) ratified the CNIC, which operates to date, although the Bill that formally created it is still

being disputed in Congress. The National Innovation Strategy (ENI by its Spanish acronym) was discussed in 2006, 2007, and early 2008 and published, subsequent delivery to the President of the Republic, with the title "Hacia una Estrategia Nacional de Innovación para la Competitividad" ("Towards a National Innovation Strategy for Competitiveness").[6] In the following section, we describe the most relevant aspects of this strategy.

3.2.2 National Innovation Strategy (ENI)

The question that the commission in charge of designing the ENI attempted to answer was: how can Chile move from a development strategy that relies solely on its natural resources endowment, to another one which bases sustainable long-term growth on the exploitation of knowledge and innovation, in order to reach the objective of doubling the per capita income within a 15 years period, a goal which the country has only achieved once during a similar period of time (16 years, from 1988 to 2004)?

- As mentioned previously, the first approximation of what definitely became our ENI took place in 2007. Among the participants in the process, there was consensus regarding the following issues: the need to establish private–public alliances.
- The importance of public support for business innovation.
- The importance of cooperation and coordination between different actors (clear examples of this are the link which should exist between the academy and the production sector, and between the national production apparatus and the international frontier of knowledge, in order to adopt new technologies).
- Evolutionist view: Public policies must be designed considering the development status of the SNI. This suggests that the SNI must be constantly evaluated.
- From the geographical point of view, it is important that regional specialization is consistent with the perspective and priorities defined by the ENI, at a national level.
- Design the institutional system for innovation support, considering that just as there are flaws in the market, there are also flaws in the State.
- Selectivity (picking the winners): On this subject, there has been less consensus but as we mentioned previously, this was the perspective which prevailed during this period (but not in the period from 2010 to 2012, as will become apparent in the following section). We will now expand on this point.

The opinion of the CNIC between 2006 and March 2010 considers that in order to increase productivity and long-term growth, Chile must prioritize four axes, each of which has a specific focus (Table 1).

[6] The Strategy was published in volumes (years 2007 and 2008), which can be downloaded from the CNIC website (www.cnic.cl).

Table 1 Priority and its specific focus

Priority axis	Specific foci
Infrastructure and resources	Development of new energy sources, water supply, infrastructure for transportation and telecommunications, and logistics
Legal and regulatory framework	Respect for property, competition regulations, labor and environmental regulations, transparency, in the public and private sectors
Financing and trade	Development of the capital market, access to the foreign financial market, access to markets (integration and trade agreements)
Technologies	Chemical engineering in food processing, TICs, biotechnology, nanotechnology, and genomics

3.2.3 Development of Clusters Based on Natural Resource Sectors

The ENI represented a definitive approach toward a more selective policy, in the measure in which it suggests focalizing resources in sectors (clusters) with higher competitive potential.

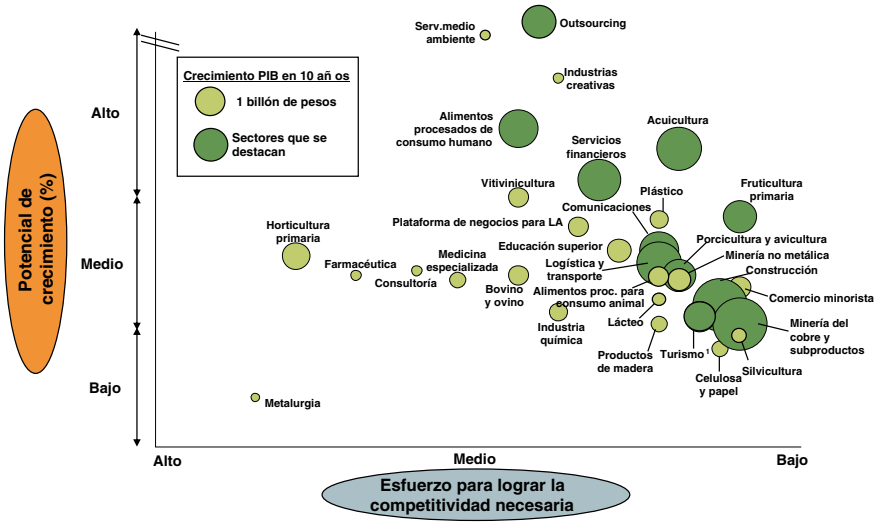
In this way, the ENI does not propose "abandoning" natural resources, but recognizing that by initiating with these, and then adding value through technology, innovation, and human capital, we can create a competitive economy for the long term.

Clusters are formed by companies that manifest different levels of development and invest in different stages of the production chain for a particular industry. These companies collaborate and develop innovation initiatives which favor the sector as a whole.

Initially, these firms are focused on exploiting natural resources without including added value, but they later develop skills and employ advanced human capital, which allows them to compete in the international market of products and services that are knowledge-intensive.

The criteria used to define the "winning sectors" were basically the growth potential for the following 10 years, and the effort required to achieve and maintain this growth is time.[7] Based on these criteria, the information relating to a

[7] On one hand, the variables related to a comparative exercise carried out by BCG based on their experience and knowledge about sectors with high potential, independent of the country, over a fifteen year period. This selected 100 sectors which according to the representatives of BSG from a large group of countries tended to indicate greater growth potential. Besides this, in terms of relative effort, the values of 76 variables were recorded in order to assess the relative effort the country would have to make in order to become a relevant actor in these 100 sectors. These were condensed into a single index (among these variables, we mention the weight of each sector in the economy, the number of patents requested and registered by the country, and the number of doctorates and doctorate programs within the discipline). Thus for example, the index result for aerospace nanotechnology was very low. In contrast, the index was very high in mining and global services.



(1)Dentro del sector de Turismo fue considerado el subsectorde Turismo de Intereses Especiales, que tiene un dinamismo mucho mayor que el sector de Turismo tradicional

Fig. 1 Cluster definition criteria

series of production sectors was mapped, and in the end, the following 11 sectors were selected: processed foods for human consumption, copper mining and subproducts, outsourcing, aquaculture, financial services, logistics and transportation, primary fruit cultivation, communications, pig farming and poultry farming, tourism, and construction (see the Fig. 1).

The set of supporting instruments, human capital formation, and investment in physical and technological infrastructure were directed towards these sectors.

A second selection stage considered priorities as defined at a regional level. These priorities did not necessarily have to coincide with those defined nationally. For example, Special Interest Tourism was defined as a priority by the entities selecting for Region IX (La Araucania), and coincided with nationally defined priorities. However, Tertiary Education, defined as a priority in Region V (Valparaiso), where the formation of a development pole in the region based on university activities was proposed; however, it was not considered a priority from the national point of view.

Likewise, a series of strategic programs was implemented, directed toward the clusters, among which the following stand out:

- National program for diversification of the aquaculture industry.
- Research and Development Programs for pharmaceutical products and genetic selection strategy, in order to improve the health conditions of the salmon industry.
- Special Interest Tourism Programs in geographically extreme regions.
- Development and improvement of the variety program for fruit exportation, corresponding to the genetic improvement formulas worldwide.

- Technological development program for the mining industry, with the objective of improving the mining operation processes and plants.
- Strengthening of reference laboratory networks and meteorological knowledge, for the food industry.
- Program for creation of pilot skills and for the evaluation and adaptation of renewable energy projects at a pre-commercial stage, linked with foreign research centers.

The lines of strategy defined by the CNIC for the period 2008–2010 included: formation of human capital, investment in science with "strategic orientation," and business innovation. The Table 2 summarizes the priorities associated with each of these objectives:

Regarding the institutions, efforts made during this period were directed toward the consolidation of a model which would (i) guarantee the coherence of policies (considering the systemic character of innovation); (ii) define strategic objectives; (iii) clearly define the roles of each agent in the system (this explicitly recognized that the State had to correct market and coordination flaws and that public intervention should include certain elements of selectivity); (iv) assign resources in a manner consistent with the strategic objective (avoiding failures on the part of the State, which would require the adoption of better practices in terms of controllability, evaluation, and accountability).

This period ended with a proposal from the CNIC to consolidate a SNI based on the Labor Division Model, both an Inter-Ministerial Committee at a higher level to serve as supervising and coordinating body, and the subsystems of Education, Science, Business, and Entrepreneurship of the CNIC. An attempt was also made to strengthen the implementing agencies (mainly CONICYT and CORFO), clearly defining the role and jurisdiction of each and subjecting them to continuous evaluation (every 4 years) by an External Expert Committee, supervised by the Inter-Ministerial Committee and in coordination with the CNIC. The corporate government of each of these agencies must be incorporated in a board of professional experts in each area, including scientists, academics, and businessmen, the majority of which must be assigned by the Inter-Ministerial Committee.

In this way, it was to be expected that that the implementation of policies would be clearly separated from their design, facilitating accountability on the part of the implementing agencies, by permitting the monitoring of their work by applying explicit indicators, and conditioning transfers through performance contracting (conditional transfers), and confronting the problems of agency and capture, as decisions would be made by the Higher Committee and not by the corresponding agency of implementation. The institutional design had certain additional elements, such as combined participation of agencies on the Boards (for example, the CEO of CORFO participating on a Board for CONICYT) in order to avoid problems of capture, as well as of members of the Inter-Ministerial Committee on the Board of certain agencies, thus facilitating coordination. Likewise, in the case of a number of Boards, the presence of certain sectorial Ministries is fundamental (for example for the Ministry of Agriculture and the Agrarian Innovation Fund, FIA by its Spanish acronym).

Table 2 The priorities associated with the objectives

Strategic line	Objective	Priorities
Human capital	Establish a continuous training and education system, accessible and of high quality, which allows the country to have the human capital that the economy of knowledge demands	• Promote university education, beginning with careers in engineering • Facilitate access to tertiary education for the three lower-income quintiles • Implement systems of information about higher education and the work offer and demand • Implement a work competency system, guaranteeing that all clusters maintain competence standards and that the number of certified workers is tripled • Design a crediting system based on competencies in the area of technical formation • Develop programs that are in line with international standards and have a focus on continuous education • The university education system must progress not only at a national level, but at a regional level as well
Science with a strategic orientation	Strengthen a platform for the creation, diffusion, and application of knowledge in a permanent effort of coherent research consistent with the production and social problems of the country	• Define production and social priorities in order to direct strategic research • Develop long-term scientific skills and research programs based on the priorities derived from the clusters, as well as important social problems • Strengthen and/or develop the scientific infrastructure: shared scientific service centers and access to the international infrastructure • Strengthen the advanced human capital by way of grants, attraction of international researchers, and support for the reinsertion of researchers in academic and industrial areas

(continued)

Table 2 (continued)

Strategic line	Objective	Priorities
Business innovation	Consolidate a business system focused on the creation of value by way of innovation as a strategy toward competitiveness in global markets	• Diffusion and trade of technology: For this, a key factor is the creation of bridges between scientific and technological skills and the production and service sectors • Strengthen the formation of trainers in innovation management • Support the development of innovative businesses • An aspect of these priorities is associated with clusters (e.g., developing a vaccine for salmon farming, new fruit varieties, bacterial bioleaching in copper mining) • Another aspect of these priorities derives from the great concerns of society (e.g., health, population aging, and development of the energy matrix) • Other priorities are associated with the objective of developing clusters linked to natural resources (such as astronomy, Antarctica, the study of volcanoes, and ocean research)

The CNIC also proposed an Agenda for the period from 2010 to 2020. This proposal was a response on the part of the CNIC to the fact that during the administration of Bachelet, the Inter-Ministerial Committee did not function correctly; the Minister of the Economy did not assign it sufficient importance and the Committee held meetings sporadically. In response to this, the CNIC assumed a more executive role, and this same activity was translated into an agenda proposal, including an operational view concerning concrete actions that in the opinion of the CNIC should be carried out by the Executive, making it possible for the strategy to be implemented.

Lastly, it is important to highlight the evaluation carried out by a panel of experts headed by Morris Teubal, concerning the situation in Chile in the context of innovation, science, and technology, the results of which were delivered in March 2010. This study alerted us to the redundancy of the indicator that measures expenditure in R&D as a percentage of GDP (0.5 %), and the limited contribution made by the private sector in this area (0.16 %). Likewise, based on the results of a survey involving 4,000 companies, it was observed that a percentage of firms presenting any kind of innovation in terms of products, processes, commercial, or management innovation fell from 38 to 19 % between 2006 and 2010. The cause of this fall in innovative performance is not entirely obvious. A number of hypotheses have indicated reasons, such as the economic cycle (the 2008 crisis is part of the observed period), sampling problems in both surveys (technically more difficult to prove), or symptoms of the Dutch disease. However, a change of strategy was never implemented as a response to this innovative performance at a company level; this change simply represented a change in view regarding these subjects. Lastly, the report emphasizes the alarm caused by the fact that our strategy still depends significantly on the export of natural resources with little added value and mentions that due to this, the effect of price surges in commodities over other non-traditional export sectors has been negative (currency appreciation and the resulting "Dutch disease") (see Teubal et al. 2010).

The mentioned study also included the SNI diagnostic regarding institutions and delivered a set of short-term recommendations, among which are the following:

- Consolidate the institutional model by including objectives for the CNIC, ratifying its autonomy to develop and supervise the implementation of the National Innovation Strategy, and its responsibility for the monitoring and assurance of the coordination between different programs.
- Introduce programs and instruments that pay more attention to the capacity of endogenous innovation than companies.
- Develop programs with the objective of developing a critical mass of innovative SMEs linked to large companies as principal suppliers.[8]
- Reform the research financing processes in order to increase its proportion directed toward national development needs.

[8] Certain efforts were made in the 1990s in this context; concretely, CORFO administered a program called Supplier Development Program (see Muñoz 2009).

- Increase gains from productivity at the level of specific clusters and improve collaboration between firms, and between the firms and the government, at the level of each cluster.

The panel also delivered recommendations for the medium and long term, among which we mention the following:

- Develop strategies to strengthen the venture capital industry directed toward the initial stages of business development around a critical mass of innovative SMEs.
- Develop a work framework which permits the formation of clusters and the diversification of production.
- Analyze needs and develop strategies and political and regulatory frameworks to provide incentive for innovation and the development of transversal platforms, especially regarding the communication networks, in order to link research institutions and companies.
- Continue to stimulate the emergence of regional skills for development, creating "learning regions" that can contribute more actively to a more differentiated innovation strategy in the future.
- Develop strategies and execute programs in order to incorporate the highest stock of advanced human capital in the research sectors and in companies.

As we will see, the new government office was initiated in March 2010 and ignored a large part of the recommendations included in this report. We will see that this reaction is due in great part to profound differences of opinion regarding the way in which public support should be adopted in this area, as well as to the role of the CNIC.

3.3 Institutional Framework for CTI Support as of March 2010

The role of the CNIC changed with the arrival of the new government. During the first 6 months of the new administration (between March and August 2010), the Council met very sporadically, and great effort was required to rearticulate it. Below we present the principal milestones in this process.

In March 2010, the new president of the CNIC was named. As we have mentioned, the Law which created the CNIC has not yet been approved by the Legislative branch, and the President of the Republic may change his position by way of a Supreme Decree, clearly contrary to the Council's necessary independence. It was precisely by way of a Supreme Decree that the new president of the CNIC was named, and he kept only three of the 14 counselors, eliminating all others. This radical change obeyed the view of the new President of the Board (and of the new government to be precise) that the CNIC should act only as an advisory board. Effectively, the new administration criticizes the vision of the CNIC up until March of 2010, considering it too focused on academics and economy, and because it gives priority to the view of public CTI support policies. It is for this reason that

the new administration simply decided against making visible the long-term agenda proposed by the previous CNIC President, instead establishing a new concept of the role of the Council, a role which, by the way, is much less relevant in terms of its orientation capacity regarding the activities of the public world in this area.

In practice, the CNIC, which existed from its initiation until March 2010, simply disappeared:

- The CNIC no longer played a role in budgetary and agenda issues, and ceased to serve as reference for a series of public institutions.
- The "new" CNIC does not believe in prioritization and selectivity, or in regional specificity. This explains why the new administration questions the cluster policy. This generated conflict with "the older ones" who were kept as counselors.
- The new Council put an end to the Broad Technological Diffusion Program (World Bank) and ignored the suggestions of the panel of experts led by Morris Teubal, who, as we have mentioned, delivered their report on the role of institutions in 2010 (see Teubal et al. 2010).
- Also, following the earthquake in February of 2010, priorities became short term. The SNI growth rate was decreased from 12 % to 2–3 %, and the CNIC budget grew less than the global rate.
- Partly because the present government does not manifest a special preference for innovation subsidy, the basic science budget has experienced unbalanced growth (CONICYT continues to grow, while the INNOVA project is stagnant, or may even have diminished).
- Within the innovation budget (and not that of S&T), there has been a reorientation toward credits (which have replaced subsidy programs) and toward a production elite. Examples of this are the following: (i) the Start-Up Chile Program, oriented toward new companies with technological content and high potential for growth and (ii) credit tax for R&D (Law 20.241), to which mainly the companies investing in R&D have applied, which are precisely more advanced and of larger size.
- On the contrary, less attention has been paid to softer innovation, more concentrated among smaller companies. This predicts an even more deficient panorama in terms of the indicators.

There are also some positive aspects of the CTI after March 2010, which are important to mention:

- During the new administration, the Inter-Ministerial Committee, headed by the Minister of the Economy, has functioned more adequately and effectively than during previous administrations.
- The budget for 2013 (declared officially the Year of Innovation) is recovered (here, we believe that "pressuring" the CNIC has been a determining factor), although this recovery is concentrated mostly on basic science.
- The regional issue is also gaining importance. In fact, as of 2013, the regional FIC will pass directly to the regions, and the GOREs (Regional Governments, by its Spanish acronym) will discuss a significant portion of the budgets locally, and the central office will not have the right to veto decisions.

3.4 What can be Seen by the Pre- and Post-March 2010 Experiences?

- In the first place, the Law must be approved which formally constitutes the CNIC and establishes it as an autonomous entity of the government in turn (by appointing presidents and counselors regardless of time). Removal, by way of Supreme Decree, of practically 80 % of the counselors of the CNIC, illustrates the importance of having the above-mentioned legal framework.
- If the CNIC does not actively and bindingly participate in the budgetary discussion, efforts made in this area will not prosper. From March 2010 to 2012, it was not so much that the Government ignored CNIC suggestions regarding the budget rather the CNIC did not even discuss budgetary issues! Only recently did it begin to have influence in terms of defining the 2013 budget.
- Regarding the previous point, it is essential that the Inter-Ministerial Committee be in charge of the entire budgetary issue for all the agencies and that the discussion in this instance be binding from the budgetary point of view. That is, the budget must be "discussed and decided on" in this instance.
- Regarding the institutional framework:
  - It is necessary that the Inter-Ministerial Committee (CM according to its Spanish acronym) should not consist only of ministers, but also include representatives from the areas of science, universities, and businesses and at least two CNICI Counselors (not necessarily the president). According to this scheme, the CM would have the function of assigning priorities (and therefore, budget) and coordination, and the CNIC (headed by the Minister of the Economy, but including non-governmental members, including key members of the National Science Academy, who must have a right to vote) should assume the tasks of foresight in the context of innovation, markets, and technology as relevant to the Chilean economy (intelligence for innovation), while continuously evaluate the performance of the SNI.
  - In this way, the CNIC would become more removed from the contingency and could thus concentrate on long-term prospective work and evaluation, while also keeping a systemic overview of public policies. Furthermore, the consistency of this long-term view would be favored by the Inter-Ministerial Committee's decisions, as the CNIC would represent this instance.

4 Conclusions and Remaining Challenges

Internationally, the discussion concerning the area of scientific and technological development has concentrated on the institutional structure of the SNI. Thus, it is possible to distinguish the different models of public support for innovation, often each with its advantages and disadvantages.

In Chile, by the year 2005, a set of policies and programs had been devised, whose impact had been generally well evaluated, but sufficient attention had not been paid to the architecture and efficiency of the SNI. However, from that year onward, a series of important changes began to be implemented in the system at the strategic level, with the creation of the CNIC, the Inter-Ministerial Committee for Innovation and the FIC. These changes represented a significant advance in the definition of a long-term strategy in this area and permitted the establishment of the institutional model's basis.

This advancement was interrupted in March 2010, when the present administration initiated and a drastic change has since been observed concerning strategy as well as the policies, as well as a decline in the relevance of the role that the CNIC had played until then. This reflects a change in view concerning these issues, which is consistent with the discourse concerning development strategy and the complementary role played by the State. Effectively, even though the present government is in agreement that a public intervention in the area of science, technology, and innovation is required, it also states that this should occur on a much more limited scale, and must be completely neutral between sectors.

This is serious from the point of view of the institutional strength of the S&T support system, and therefore, the CNIC, as supervisor of long-term execution of the ENI, was not able to pass the test of a change in Government. The present government appreciates the functions of consultancy, but not the function of supervision, of the CNIC or its demand for accountability.

Among the pending challenges regarding institutional consolidation, we may highlight the passing of the Law which formally constitutes the CNIC, the regionalization of the innovation strategy, and rationalization of the operational level of the SNI. Let us consider each of these three challenges separately.

As we have mentioned, the strategic level of the SNI is still awaiting legal institutionalization, as the law it depends on has been pending legislative procedures for seven years. We need to speed up the legal discussions regarding the stability of the proposed structure for the CNIC, in order to guarantee that the proposals and designs established up until now remain for the long term. This issue is the most important, as the lack of clear long-term signals affects not only the decisions of companies interested in these aspects, but also the decisions of other entities such as technological institutes, higher education entities that need to define their offer to train qualified human capital, and agencies, offering grants to exceptional students.

Likewise, given the territorial character of some of the proposals for public support for innovation, it is urgent to implement an institutional framework that supervises the pertinence, consistency, and transparency of the local assignment public resources. This is also a pending challenge that is highly relevant, as the law of FIC establishes that a percentage of remuneration associated with mining royalties would be directed by each region. Therefore, it is necessary to define strategic priorities at a local level, assigning the corresponding funds, and ensuring that regional institutionalization adequately supervises the execution of various initiatives which receive funding.

The rationalization of support programs and instruments related to innovation, both nationally and locally, implies the fusion and/or transfer of these instruments and products between intermediary agencies, when scale and scope economies exist but have not been exploited or suffer from evident coordination problems. In this area, the authorities are expected to evaluate cases where this type of situation presents itself and take the right decision in order to avoid problems of capture.

Only if we are able to make progress in these areas (legislation, operational rationalization and regionalization), will the institutional framework of science, technology, innovation, and entrepreneurship be able to operate relatively independently of the political cycle, face the problems relating to agencies within the system, and decrease the risk of capture by interest groups.

References

Benavente JM et al (2005) Rates of Return for Industrial R&D in Chile. Universidad de Chile, Santiago de Chile

Benavente JM et al (2007) The Impact of National Research Funds: An Evaluation of the Chilean FONDECYT. Office of Evaluation and Oversight (OVE)—IDB, Washington DC

Easterly W, Levine R (2002) It's not Factor Accumulation: Stylized Facts and Growth Models. In: Loayza N, Soto R (eds) Economic Growth: Sources, Trends and Cycles. Central Bank of Chile

Fagerberg J, Verspagen B (2003) Innovation, Growth and Economic Development: Why Some Countries Succeed and Others Don't. Manuscript presented at the Innovation Systems and Development Strategies for the Third Millennium conference in Rio de Janeiro, 2003

Freeman C (1982) The Economics of Industrial Innovation. Second edition. Pinter, London

Hall R, Jones C (1999) Why Do Some Countries Produce So Much More Output Per Worker than Others? Q J Econ 114(1):83–116

Klenow P, Rodríguez-Clare A (1997) The Neoclassical Revival in Growth Economics: Has It Gone Too Far? NBER Macroecon Ann (12):72–103

Lederman D, Maloney W (2003) R&D and Development. World Bank, Washington DC

Lundvall B-A (1985) Product Innovation and User-Producer Interaction. Aalborg University Press, Aalborg

Muñoz O (ed) Desarrollo Productivo en Chile. La Experiencia de CORFO entre 1990 y 2009. CORFO/FLACSO-Chile/Catalonia, Santiago

Nelson R (1993) National Innovation System: A Comparative Analysis. Oxford University Press, New York

OECD (2007) OECD Reviews of Innovation Policy: Chile. OECD, Paris

Romer P (1990) Endogenous Technological Change. J Polit Econ 98(5)

Tekes (2002) Benchmarking innovation systems: Government funding for R&D. Technol Rev 122

Teubal M et al (2010) Evaluation report of national innovation strategy for competitiveness. Chile

Insights into the Impact of BID's Technology Modernization Program on Argentina's STI Policy

Gustavo Lugones, Fernando Porta and Darío Codner

Abstract Since the mid-1990s, policies on science, technology, and innovation (STI) have recovered an outstanding place on the agenda of Latin America countries. Several changes have taken place in both institutional systems and policy regulation, planning, and coordination agencies. At the same time, new instruments for the promotion of scientific research and technological innovation in the productive sector were incorporated. International lending agencies such as the Inter-American Development Bank (IDB) played an important role, especially in Argentina where specific policies and instruments were developed and implemented through successive versions of the Technological Modernization Program (PMT). This chapter shows the results of the evaluation of this program and its main instruments in the last 10 years carried out by experts from Quilmes National University. The evaluation shows that the program implementation has strengthened both scientific and technological capabilities of the country and that it has also increased the competitiveness of the productive sector through the production and incorporation of knowledge and technology. In short, the implementation of PMT III has contributed to the development and strengthening of the National Innovation System and the Regional Innovation Systems in Argentina.

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1 Introduction

Based on a different approach from the one that had characterized them in their origins, science, technology and innovation (STI) policies recovered, since the mid-1990s, a prominent place on the agenda of Latin American countries (Cimoli et al. 2009). Several changes were introduced in both institutional systems and policy regulation, planning, and coordination bodies. At the same time, new instruments for the promotion of scientific research and technological innovation in the productive sector were incorporated. International lending agencies such as the Inter-American Development Bank (IDB) played an important role, providing technical assistance for the design and implementation of programs as well as funding for their execution. In Argentina, for example, specific policies and instruments were developed and implemented through successive versions of the Technological Modernization Program (PMT).

During the 1990s, STI policies implemented in Argentina were based primarily on a "demand" approach, with political prominence and relative horizontal displacement of sectorial policies that had prevailed under the "producer" state and the import substitution model. Thus, some institutions responsible for the regulation and management in the field of science and technology were redefined, and new ones were created: the Science and Technology Cabinet (GACTEC), some technological liaison units (UVT), the Secretary of State for Science, Technology and Productive Innovation (SECyT), which has become a Ministry (MINCyT)—and the National Agency of Scientific and Technological Promotion (ANPCYT). New funding for R&D and several liaison activities between institutions of the scientific and technological system were generated, and scholarships as well as fellowships devoted to train highly qualified human resources were extended. As a result, both FONTAR and FONCYT funds implemented by the ANPCYT have become nodal points of STI policies.[1]

In 2000, as part of this institutional learning path, specific instruments within a long-term strategy were organized by defining objectives and goals more accurately, by developing a more systemic approach, by broadening and diversifying the scope of eventual beneficiaries, and by paying close attention to impact issues. At the same time, a prioritization approach of some strategic sectors was taken up again and some vertical policies were considered in order to be redesigned. Furthermore, MINCyT's decision of going further in the implementation of "sectorial funds" must be understood as part of the STI policy evolution process. The international experience shows that, after a certain period of implementing horizontal policies, many countries have started a transition toward more focused

[1] FONTAR administrates resources coming from different origins to fund projects aimed at productivity and competitive performance improvement in the private sector based on incorporating technological innovation activities. FONCYT is in charge of managing resources to fund technology and science research projects by means of promotion mechanisms open to all researchers, regardless of the institution they belong to.

policies, which specialized literature suggests is part of the necessary evolution toward greater impact policies in accordance with innovation processes maturity.

This chapter is based on the results of several assessment activities of PMT in Argentina and its main instruments, carried out by Quilmes National University specialists during the last 10 years. A reflection on those results is presented in the different sections. The first section includes considerations about both processes and assessment methodologies, and the second presents the main features of the National Innovation System (SNI), Argentina's productive structure as well as the path of some science and technology promotion policies which have produced effective results in recent years. The third section describes and analyzes the process of transition from one scientific and technological system to an innovation system which started with the creation of the ANPCYT and its subsequent functional hierarchy of policies under SECYT conversion into a ministry. The fourth section specifically develops an assessment and analysis of the PMT, its main instruments, and their corresponding impact. In the final section, there are some conclusions drawn from the whole process.

2 Increasing Importance of Policy Assessment

As part of the strength acquired by STI policies in Latin America over the last years, countries from the region have recently begun to develop assessment activities of promotion programs and instruments. In view of some approaches that tend to confine the evaluation process of public policy in an attempt to reduce the deficit of information of decision makers, or raise awareness of the design of objectives and goals, it was thought that the assessment should become a specific form of coordination between actors, so as to enable the development of interactions and mutual learning, resulting in a potential tool for strategic management (Sanz-Menéndez 1997).

Within the evaluation procedures applied in the case of programs for fostering technological modernization and innovation, a distinction should be established between quantitative and qualitative approaches; the latter often based on case studies and useful for understanding the specific institutional frameworks in which the instruments are implemented. At first, evaluations of technology promotion programs tended to rely on this type of analysis since its main objective was testing the efficacy of these policies rather than their efficiency, and therefore, no progress was made in cost-benefit estimates (Cardenas et al. 2000; López 2009). More recently, and mainly from the implementation of econometric techniques, there has been significant development of a quantitative analysis, including the estimation of the internal rate of return of the policies implemented, considering also its costs and benefits. Certainly, the articulation of quantitative and qualitative techniques allows a better assessment of innovation-fostering programs since uncertainty of the results is the norm in this activity (Peirano et al. 2007).

Estimating the additionality effect of public expenditure on private expenditure is one of the traditional ways of assessing public programs for fostering innovation and technological development. In the case of measures to encourage R&D, its impact on firm R&D expenditure should be calculated estimating how their behavior would have been in the absence of public subsidy. The difference between the observed situation and its counterfactual one would represent the additionality attributed to government intervention (Georghiou 2002, 2004).

In this sense, four types of additionality have been identified: (1) of input (2) of product, (3) of behavior, and (4) of cognitive ability. The first two types have their main origin in the neoclassical approach of "market failure" present in innovation and technological change activities, while the rest are closely linked to the so-called evolutionary theories which emphasize the learning process at firm level.

The concept of input additionality applies to the evaluation of the possible effects of complementarity (crowding in) between public and private funding for innovation, or substitution (crowding out) of the second by the first. In turn, the concept of product additionality tries to estimate the firm effectiveness for obtaining innovations and, therefore, aims at measuring the number of innovative products created as a result of the existence of public subsidy. In this case, specific indicators, such as patents obtained or new products or prototypes generated, and general indicators of the firm's performance such as sales, profit, productivity, and exports are used. Furthermore, there are many variables that mediate between obtaining a public subsidy to encourage innovation and results of the firm in terms of innovations. Thus, this type of linear approach (input applied to generated output) becomes somewhat reductionist in appreciating the complexity of the firm innovative process; however, most econometric studies on the subject are based on them.

The concept of behavioral additionality (OECD 2005, OCDE 2006) arises from theoretical developments which have emphasized the dynamic, interactive, and cumulative character of the innovation process (Dosi et al. 1988; Lundvall 2009, Nelson and Rosenberg 1993) and inquires how agents assimilate and exploit their R&D activities. In this sense, it focuses on the long-term behavior of the firm which has received a subsidy for that purpose, rather than examining immediate results (products). This approach reflects on the degree of institutionalization of R&D in the firm, the establishment or strengthening of links between firms and their suppliers, customers and S&T government agencies, research networking, the improvement of access to external sources of financing, or the acquisition of new skills in management and *marketing*, among other possible externalities (López 2009). Although these arguments have existed for nearly two decades, the empirical evidence based on this approach is still quite recent.

The concept of cognitive additionality has appeared more recently and is usually regarded as a subtype of the former. It has its origin in the theoretical framework of evolutionary schools and seeks to deepen the analysis of the different dimensions of the firm's own learning processes. It consists of a more descriptive approach about qualitative information which attempts to account for the processes needed for exploration, ownership, operation, and management

of new knowledge by economic agents (Afcha Chávez 2011). It should be emphasized, though, that an understanding of the changes in business strategy regarding innovation activities is crucial to improve the design and implementation of policy instruments in order to promote both innovation and technological development, especially when seeking to strengthen the establishment and articulation of collaborative networks among different actors in the National Innovation System.

The evaluation of programs which support technological innovation is more widespread than that devoted to means for promoting scientific and technological research. Many of the institutions fostering scientific development created in the countries of the region since the mid-twentieth century relied on an approach based on the autonomy and freedom of scientists to set their own research agenda (Sarewitz 2010; Stokes 1997). Within this model, the evaluation of policies supporting scientific research could only be done by the scientific community. In the case of Argentina, the creation of ANPCYT in 1997 involved, in certain way, some change in perspective. Although the allocation of funds devoted to projects by the ANPCYT is mainly based on an academic excellence criteria evaluated by peer review, the introduction of criteria regarding the social relevance of research and the importance of funding from multilateral lending agencies have boosted the development of some forms of assessment also for these programs (Chudnovsky et al. 2006b).

These assessments tend to use econometric techniques to measure the impact of the program in terms of the academic performance of researchers, as it was originally tested in the evaluation of scientific promotion programs in developed countries (Arora and Gambardella 1998; Gambardella 2001; Goldfarb 2001). These exercises tend to prioritize the estimation of bibliometric indicators related to the publication of articles in international indexed journals and their impact. They are based on studies which indicate the existence of correlation between the quality of publications and their impact on innovation (Hicks et al. 2000). And although they are generally accepted, bibliometric evaluations have inter-temporality problems because of the uncertainty over the maturation period of the subsidy impact and heterogeneity problems among the different areas of knowledge regarding the ways in which the results are published. There is also an idiomatic bias in journals under consideration by most acknowledged indexing records (Crespi and Gauna 2004, 2005; Eduardo Loria Díaz 2001).

A recent study systematized an experience in evaluating public programs supporting technological development and innovation in the productive sector in Latin America (López 2009). Twelve evaluations in six countries of the region have been identified: Argentina, Brazil, Colombia, Chile, Panama, and Uruguay, seven of which used econometric techniques, three estimated economic returns, and two carried out case studies. In the case of Argentina, econometric assessments were conducted on the Technological Modernization Program I and FONCYT FONTAR (Chudnovsky et al. 2006a and 2006b), and there is also a case study on the Technological Counseling program by FONTAR (Carullo et al. 2003). These facts have been considered for the performance evaluation of PMT III conducted

between July and November 2010 by a team of specialists from Quilmes National University under the request of ANPCYT and IADB.[2]

The overall objective of the evaluation was to verify the degree of fulfillment of the targets set for the PMT III, analyze deviations and their possible causes, measure the program's impact, and draw lessons that would allow adjustments in the design and implementation process. The methodological approach aimed at assessing impact and focused on the analysis of several indicators of results. For this purpose, the following exercises were articulated: (a) use of a logical framework, operating regulations, and modificatory provisions as reference frameworks, (b) use of a methodology of control groups for implementing econometric and bibliometric techniques, (c) implementation of structured, semi-structured, in-depth interviews, (d) implementation of case studies, (e) application of a systems approach to organizational analysis, (f) econometric impact analysis to determine the existence of additionality or displacement effects in the evaluated instruments, and (g) use of sampling with statistical representation.

The evaluation of FONTAR and FONCYT instruments was carried out from the generation of qualitative and quantitative results through a combination of methods of inquiry. The information gathered was used to determine the fulfillment of the objectives for each of the instruments involved. In the case of FONTAR, this task required to identify the innovative behavior of the firms and institutions which received the corresponding benefits; to reveal the perception that beneficiaries and the agents involved in the use of the various instruments of the fund as regards the instruments themselves, the evaluation, the implementation, and the results obtained from the use of the subsidy obtained; and to estimate the social benefit of subsidized projects as well. For the evaluation of each instrument, a strategy tailored to the information available, the degree of progress in the projects' implementation, and the characteristics of the beneficiary population to be studied were applied.

Specifically speaking, this research sought to know whether FONTAR instruments reduced financial constraint and generated an additionality effect on those firm resources devoted to innovative projects and whether the results of these projects led to improve key aspects for their competitiveness such as cost reduction, access to new markets, or the development of new products or processes. It also sought to estimate the magnitude of the externalities and both fiscal and social returns of disbursed funds. Another point of particular interest was to analyze whether the projects encouraged by the FONTAR helped to strengthen social skills development and action planning in the field of innovation and to improve competitiveness. Finally, this work has also sought to identify obstacles and problems, both in the business area and in the public administration, to contribute to the process of institutional improvement and learning.

[2] Gustavo Lugones and Fernando Porta were responsible for the activity under Darío Codner's general coordination. The team was completed with Patricia Gutti, Fernando Peirano, and Marcos Gerber. Collaboration from ANPCYT's and DIB's Science and Technology Division officials was crucial for carrying out the evaluation (Porta and Lugones 2011).

In the case of FONCYT, evaluation was aimed at verifying the fulfillment of its goal of strengthening the National Innovation System and Regional Innovation Systems, by analyzing the results of the use of subsidies in terms of the scientific and technological knowledge generation in different thematic areas and in terms of possible improvements in the associative relationship between the science and technology sector and firms, or public entities that produce goods and services. Besides considering the fulfillment of objectives and goals of each instrument in response to the definition in the logical framework of PMT III, the different instruments included in this subprogram were assessed for their impact on a territorial and disciplinary level, for their impact on the scientific and technology production—identifying quantity and quality of publications and patents introduced, methods of liaison and technology transfer, and advancements in R&D institutional management and improvements—for its impact on the development of research and human resource training skills, and for its impact on the development of R&D consortia and clusters of knowledge. These different inquiries were supplemented with an analysis of the perception of the beneficiaries themselves about logic and instrument management.

3 Characteristics of Argentinean NIS

Argentina has one of the most important scientific bases in the region as well as a wide institutional tradition which, together with the existence of highly qualified human resources and important research groups located in its territory, place the country in a prominent position in the Latin American context.

Among the positive features of the Argentinean scientific and technological system, the existence of a wide and highly skilled human resource base stands out. This feature is combined with the highest gross enrollment rates in higher education in the continent. Argentinean higher education system is based on the essential role played by national universities of public management which are characterized by gratuity and unrestricted entrance as well as by their responsibility for a significant part of the research activities of the country.

The Argentinean SNI shows a low degree of coordination between its various components. The main institutions of the system were created one after the other under different areas of public administration, with the intention of addressing specific problems to which they responded in a non-systemic way (Bisang 1995). This led to the consolidation of a system that provides excellence groups in some key areas, but in a context of isolation, with little connection to those specific demands with a strong geographical and thematic focus, which, at the same time, does not favor coordination (Lugones et al. 2005).

The different programs fostering innovation and scientific activity implemented at this last stage have paid increasing attention to the correspondence between the knowledge supply and its effective practical application for the production of goods and services. Similarly, the ANPCYT has provided funding for joint

R&D projects and patenting of products through contestable funds which seek to maximize transfer capabilities, prompting the search for associations between S&T institutions and private firms.

In Argentina, the dynamics of the SNI are also affected by the low proportion of resources allocated to these activities. The total investment in R&D as a percentage of GDP for 2008 was 0.52 % in Argentina, being 0.63 % of the average for Latin America and the Caribbean, 0.75 % for Chile, 1.09 % for Brazil, 1.34 % for Spain, 1.85 % for the European average, and 2.77 % for the USA (RICYT 2010). In Argentina, this trend is growing after the crash in the context of the 2001–2002 crises, taking into account that it was not until 2005 that the 1999 levels were exceeded. Similarly, the level of spending per researcher is clearly lower in comparison with the countries mentioned above. This feature determines the research scope and depth, limiting its potential, further restricted when considering the high degree of institutional research concentration.

In turn, the rate of highly qualified staff devoted to these tasks in the private sector remains marginal. Existing records indicate that in Argentina, it is less than half of that in Brazil and about one-third of the Latin American average. This goes hand in hand with the low participation of the private sector in total funding for R&D: Expenditure on R&D from private firms reached 26.5 % of the total in 2008, compared to a 41.2 % of the Latin American average, 43.9 % in Brazil, 45.0 % in Spain, and 69.0 % in the USA (RICYT 2010).

In spite of the challenges faced by STI policies to overcome the weaknesses and restrictions present in the SNI, the evolution of expenses on both scientific and technological activities in recent years should be noted as a favorable aspect. Additionally, the Argentinean educational system, as well as many S&T institutions, has a remarkable tradition in training resources. The scope of the higher education system in Argentina undoubtedly contributes to the generation of a growing supply of highly skilled resources. Furthermore, the existence of a relatively large group of firms operating in intensive knowledge fields and maintaining strong ties with academia constitutes another promising feature.

After the crisis of 2001/2002, Argentina's economy began a sustained recovery in which most productive activities contributed positively to an increase in output and investment, the generation of employment, a rise in wages, and an increase in exports. Once a growth dynamic based on the simultaneous expansion of the domestic market and exports was set up again, the challenge turned toward escalation of activities, internal production, sector densification, higher quality of the working process, and higher added value.

It is already known that productive specialization is not neutral in terms of income growth and distribution. In this sense, it is evident that an increase in social cohesion and equity, sustainable exploitation of natural resources, renewal of competitiveness sources, and knowledge inclusion in every productive activity are the current priorities in Argentina. These challenges require increased scientific and technological skills in the country.

Given the heterogeneity of the Argentinean economic and social structure, generating competitive advantages requires the implementation of a diversified

and complex productive policy agenda. This is where STI policies find their main justification and role. In addition to increased investment in education and skilled resources plus the promotion of scientific and technological development, it is important to reduce the risk and uncertainties associated with the generation and application of innovations and provide an environment favorable for spreading virtuous innovative strategies.

Undoubtedly, the creation of MINCyT in the late 2007 implies both a political and institutional hierarchy of this issue and points out the beginning of a stage in which the Ministry should contribute to the provision of feasible answers to three interrelated questions which arise from (1) a challenge in an international competition process in which innovation and technological change plays a central role; (2) the need for a generalized scaling in Argentinean productive structure based on knowledge inclusion into processes, products, and organizations; and (3) the context of strengths and weaknesses that characterize the SNI in Argentina.

4 From a Scientific and Technological System Toward an Innovation System

Changes in higher education policies first and then changes in science and technology were implemented toward the middle of 1990s. They followed their own logic and took place rather independently from changes in economic policy characterized by the implementation of the set of structural neoliberal reforms based on guidelines established by the Washington Agreement.

The creation of a Secretariat for University Policies (SPU) in 1993, with power to act, was the first step toward a greater regulation and guidance of teaching and research activities in universities. In 1996, a process to extend the reform to science and technology institutions began. Thus, boosted transformations focused on the institutional framework and on their attempt to modify their operating logic. The reform program was framed around three main areas:

a. Concentration of the functions of policy making, planning, and programming in SECYT. A new institutional structure for SECYT was enacted, and the development of a multiyear plan for STI was launched.
b. Creation of ANPCYT in order to carry out promotion actions through the distribution of resources devoted to fund firms' research projects and technological update.
c. Improvement of inter-ministerial coordination in science and technology activities and inter-institutional coordination toward their own sector bodies. GACTEC was created within the scope of the Cabinet of Ministers as an inter-ministerial coordination body and the Inter-institutional Management Committee of Science and Technology as a coordination instance among the several scientific and technological bodies.

The most important political action was the creation of the ANPCYT in 1996, which began operating in 1997. From then on, innovation has become the center of science policy with a strong criticism to the linear model which supported R&D supply that prevailed until that moment, putting forward its replacement for supporting R&D demand by firms.

The low private expenditure on science and technology activities that characterizes Argentina is closely associated with the country's economic profile. The most productive activities in the country have either reduced their costs and their technological dynamism or focus their efforts on R&D in their headquarters. While, in recent years, industrial growth and efforts from some government agencies tried to reverse the trend, the scope and depth of the results is still not enough to improve the relative position of our country.

International funding remains important for STI programs in Argentina. The IADB, in particular, played a leading role through the funding of the different stages of the PMT.

It is likely that the changes generated by the creation of the IDB ANPCYT and their influence have affected the scientific system orientation toward innovation systems.

The institutional recovery process was particularly remarkable in the case of CONICET, the main R&D implementing agency in the country which since 2002 has developed an important process of institutional expansion and strengthening.

The institutional and budgetary recovery process also affected other historically decentralized R&D executing agencies, such as the Agricultural Technology Institute (INTA), the National Atomic Energy Commission (CNEA), the National Space Activities Commission (CONAE), and, to a lesser extent, the Industrial Technology Institute (INTI).

The new stage was characterized not only by the recovery of public funds, but also by a series of initiatives designed to diagnose the state of the system as well as mid- and long-term policy planning. The SECYT asked the Observatory of Science, Technology and Productive Innovation the development of Bases for a Medium Term Strategic Plan for STI which were, included in the "Bicentennial 2006–2010 National Strategic Plan for STI." The plan established a number of strategic objectives as well as quantitative and qualitative targets to be achieved between 2010 and 2015.

At the beginning of President Cristina Fernandez's administration, in 2007, the SECYT became a Ministry. The scientific community welcomed the creation of MINCYT as an indicator of higher political priority bestowed on scientific activity. The greatest attention regarding science was placed on a series of initiatives such as the enactment of a new law for educational funding which raised the level of public spending on education to more than 6 % of total GDP.

Additionally, during the last few years, there has been a relevant increase in the number and power of instruments available. However, instruments for scientific promotion replicate some of the deficits of the instruments for productive promotion such as the overabundance of low-range instruments, the coexistence of institutions and programs with different focus and approaches, and lack of monitoring

and evaluation. As a result, the most important policy challenge for the coming years is to intensify efforts to solve these faults of the public promotion system.

In short, the Argentine STI public policies have undergone major changes from the institutional framework, conceptual approach, and macroeconomic regime during the last two decades. The path of their main implementing agencies, such as decentralized sectorial bodies, the CONICET, the current MINCyT, and ANPCYT, reflects their character as essential and permanent institutions in the innovation system and, at the same time, their ability to adapt to changes and specific instrument implementation. These organizations have gone through a major institutional process of training and sophistication as regards policy instruments design and management. In particular, the Ministry did extensive work in strategic programming by broadcasting discussions among several sectors and stakeholders, and the Agency developed and incorporated new lines of action aimed at supporting clusters and value chains.

5 The PMT and its Impact. The ANPCYT, The PMT III, FONTAR, and FONCYT

5.1 About ANPCYT

The Agency was created in mid-1996, as part of an institutional transformation aimed at introducing more coordinating elements of STI within the framework of an economic openness and State reform process. The institutional redesign implied a change of the science and technology conception on which public institutions had been individually shaped: from a demand approach as system objective to an intended innovation supply approach. It also sought to increase the coordination and efficiency of the system through the expertise of its members in three main functions: development of STI policies, promotion, and STI implementation activities.

Prior to this restructuring, the main actors of the system, such as the CONICET[3] and the universities, developed all these functions simultaneously. With the reform, and the roles adopted by SECYT as policymaker, and the Agency as policy promoter, higher efficiency and a more productive impact of public investment on scientific and technological activities were expected via competition for resources among executing agencies and priority setting. The advantage of

[3] There is no doubt about CONICET historical role in promotion, that is to say, project funding according to quality. But attention to more than a hundred institutes, a scientific and technical ranks of over 6,000 people and the provision of scholarships for researchers training had hindered the proper exercise of the function of financing R&D projects, both from the point of view of the amount of resources for this purpose, and the treatment on an equal basis to all researchers, whether or not they belonged to a scientist research career at the agency. (Codner 2005; Porta et al. 2010).

having an agency exclusively devoted to promotion, without being responsible for the implementation of research and development (R&D) activities, was strongly supported by the committees formulating the "Basis for the discussion of a Science and Technology Policy" in 1996.

A singularity generated from the ANPCYT creation is that it would not only be devoted to promoting scientific research carried out by researchers, but it would also finance firms interested in implementing modernization and technological development projects, in line with what was happening in the core countries. Somehow, the Agency seeks to promote scientific research and business innovation simultaneously and complementarily, two complex phenomena with different operating logics, which until then had not been addressed by a single institution public policy.

Upon creation, the Agency introduced basic concepts for the selection of projects to be funded, including the use of open tenders, the use of pairs for evaluation, implementation of project selection criteria based on quality, merit, and relevance, the requirement of counterparts as risk-sharing mechanism and ensuring transparency and confidentiality, among others. All these elements made the agency an institutional innovation itself. ANPCYT main mission is to organize and manage instruments for the promotion and encouragement of scientific and technological development and technological innovation in the country. Thus, on the one hand, it serves researchers from universities and public and private research institutes, and on the other hand, it serves entrepreneurs and firms seeking technological modernization or new technological developments.

Currently, the Agency is a decentralized body of MINCYT.[4] The expression decentralized indicates autonomy to carry out actions related strictly to its mission. But, at the same time, it means dependence on hierarchical authority, in this case the MINCYT, and the impossibility of holding its own assets, decision making about its staff regulation, and autonomy to choose their own authorities.

Through its funds and instruments, the Agency transfers a significant amount of financial resources to beneficiaries. These resources come from different sources such as the National Treasury and external sources such as the IADB and IBRD. The Agency has four funds (FONCyT, FONTAR, FONSOFT, and FONARSEC) devoted to finance the development of scientific research, technological innovation and modernization of firms, and scientific and research institutes across the country. The portfolio of instruments has evolved over time. In the late 1990s, the ANPCYT managed not more than 6 instruments, while at present there are over 15.[5]

The FONCYT grants subsidies and scholarships to researchers, research groups, and public and private non-profit institutions to encourage the development of research projects with strong scientific and technological externalities for society. These are mostly precompetitive activities carried out mainly by universities

[4] From its creation up to 2007, the Agency has been a decentralized body from the Secretary of Science and Technology belonging to the Ministry of Education and Culture.

[5] During the first years, the Agency's financial implementation was about US$30 million. From 2007, its implemented resources are above US$100 million.

and public research centers. FONCYT resources fund researchers' training and mobility, inputs for research, the purchase of scientific equipment, and laboratories maintenance and updating. FONCYT resources are allocated through competitive tenders where there is usually a large participation of the scientific community.

FONTAR instruments include grants, loans, and exonerations, to co-fund projects of modernization, innovation and technological development for individual firms, production chains, and consortia of R&D firms and institutions. FONTAR instruments combine so as to fund different aspects or stages of firm innovation process, from activities regarding the initial technological development phase (R&D expenditure, R&D unit implementation, development of new products, materials, processes or services, testing, prototypes or pilots) to the expenditure necessary to achieve industrial scale.

The FONSOFT follows a more accurate mission than previous funds, which consists of fostering the development of the national software industry. Its instruments serve the whole innovation process, from basic research to the improvement or development of products and processes for the market. The FONSOFT grants subsidies through competitive tenders, for entrepreneurs interested in creating business connected to software and to firms seeking to improve the quality of their products or to develop new ones. In addition, the FONSOFT provides loans to encourage exports and subsidies for institutions to train their workers.

Finally, the FONARSEC, the last of the funds incorporated by the Agency, brings together elements of the previous three. Its instruments aim at fostering associative innovation such as the newest FONCYT and FONTAR, but with the aim of improving the competitiveness of preidentified strategic sectors such as FONSOFT. The potential intervention areas of FONARSEC are as follows: health, energy, agribusiness, social development, ICT, nanotechnology, and biotechnology. The FONARSEC also supports large projects submitted by a consortium seeking to solve critical problems of high impact in each of the appointed areas through competitive grants. Additionally, the FONARSEC also has instruments to encourage the development of new technology-based firms.

5.2 About the Technological Modernization Program

Two important milestones framed the creation of the Agency: the enactment of Law 23.877/91 for the Promotion and fostering of Technological Innovation and the implementation in 1994 of the PMT, funded by IADB and National Treasury counterpart. This funding had two allocations. The first operated under the SECyT-CONICET agreement and intended to grant subsidies to researchers and public R&D centers, while the second, under the Secretary of Economic Planning of the Ministry of Economics, was the Argentinean Technology Fund (FONTAR) which provided financial support to firms developing or incorporating technological innovations. Although with limited real progress in implementation, they were key for the learning which allowed the construction of ANPCYT few years later.

In 1996, PMT was reformulated and a new regulation of Law 23,877 for the Promotion and Development of Technological Innovation was implemented. This created a set of loans and subsidies to promote and encourage innovation, such as the Loans for Technological Modernization, the Fiscal Loan Regime, and Technological Counseling Program. Moreover, the Law established the conditions for the construction of a delivery system for these instruments by creating the UVT, a network of public–private institutions located throughout the country.

Within FONTAR functions, the UVT authorization was added. The UVT should aim to promote science and technology development in the country, working as a link between the productive sector and science and technology institutions in the country. The services these entities provide to the productive sector are linked to activities of project design and management. The UVT related to universities or scientific institutions like the National Institute of Agricultural Technology (INTA) and the National Institute of Industrial Technology (INTI) usually involved through testing, design, etc. Demand for services offered by the UVT comes mainly from SMEs.

Financial support from the IADB has affected institutional development through successive loan programs, which also increased their amounts: The PMT I (1993) was $61 million, the PMT II (1999) 140 million, and the PMT III (2006) 280 million. Particularly, in the context of the PMT III, FONTAR allocated resources through four instruments: (1) the non-refundable contribution (ANR) to co-finance technological innovation projects through grants covering part of the cost of the project, (2) loans to firms (CAE) of compulsory refund to strengthen technological services development capabilities, (3) the refundable contribution to institutions (ARAI), this being a compulsory refund loan to public and/or private non-profit institutions for the creation, expansion or improvements of facilities, and equipment and human resources training, and (4) the associative PI-TEC projects which fund R&D and innovation activities articulating other ANPCYT instruments. During PMT III management, the instruments described above drew on a budget of around US$205 million, of which the CAE represented 52 % of the funds, the NRA 35 %, the ARAI 10 %, and PITEC 2 %. The execution meant funding of approximately 1,600 projects (1,250 ANR, 300 CAE, 50 ARAI, and 7 PITEC).

On the other side, the Fund for Scientific and Technological Research (FONCYT) funded projects in the areas of science and technology in the context of plans, programs, and priorities set by the government for the sector. The instruments available for this fund are as follows: (1) Science and Technology Research Projects (PICT) to fund competitive R&D regarding its quality, (2) Guided Science and Technology Research Projects (PICTO) to fund R&D projects co-financed by institutions, (3) Research and Development Projects (PID) to finance projects aimed at promoting the link between research groups and the productive and social sectors seeking precompetitive innovative or high social impact results, (4) Equipment Modernization Projects (PME), (5) Strategic Areas Program (PAE) to finance high-priority “knowledge cluster” projects, (6) Human Resources Program (PRH), containing two components (PID for Researcher Relocation—PIDRI) and doctors training projects in high-priority technology areas (PFCT)),

and (7) Adaptation and/or Infrastructure Improvement Projects (PRAMIN) to fund the availability of suitable space for equipment installation and the development of activities on human resources embodied in R&D units.[6]

5.3 About Effects Produced by Instruments

Evaluation activities carried forward from Quilmes National University encompassed different PMT III program components, covering both operational and institutional aspects such as impact, and using different methodologies. The main purpose was to draw some conclusions about the impact of their implementation in different dimensions and summarize lessons that may be useful for ANPCYT future performance.

The methodological approach was directed to the impact assessment and focused on the analysis of results articulating (a) the use of the logical framework, operating regulations, and modificatory documents as reference frameworks, (b) the implementation of a control group methodology for conducting econometric and bibliometric techniques, (c) implementation of structured, semi-structured, and in-depth interviews, (d) case studies, (e) use of a systems approach to organizational analysis, (f) econometric impact analysis to determine the existence of additionality or displacement effects in instruments evaluated, (g) statistical representation of samples, and (h) analysis of technical reports submitted by beneficiaries.

5.4 Evaluation of the Impact of FONTAR Instruments

The ANR accounts for a significant degree of additionality which avoids developed projects from being postponed or reduced in scale and complexity. This instrument had a positive impact on product and process innovations, costs, indirect improvements, sales, exports, and human resource training for innovation projects. Social benefit estimates indicate that ANR helps generate social added value eleven times higher than FONTAR's contribution and fiscal return being positive since it implied a cumulative revenue that is 4.5 times higher than the fiscal cost of the contribution. The ANR has complemented private effort so that social added value grew by 1.5 times compared to what would have been achieved without the ANR. For these reasons, the equation between social benefits and costs of the instrument presumably has a positive balance. Finally, the ANR provides an effective response to restrictions on access to innovation loans.

[6] During PMT III management, FONCYT budget consisted in approximately US$250 millon for the execution of 5,215 projects (69 PID, 3,553 PICT, 632 PICTO, 158 PME, 19 PAE, 196 PIDRI, 384 PFDT, 147 PRAMIN).

The CAE has influenced improvements in existing products and processes, with modest results in terms of new products or processes. It helped improve the overall performance of the beneficiaries, with high impact on cost, efficiency, activity level, market share, and exports. The CAE eased loan constraints for the development of technology-based projects, the main attraction being the low cost and the effects of financial complementarity. FONTAR strategy to use commercial banks as intermediaries was right: Half of firms state that they did not know FONTAR and that they accessed CAE upon contact with their commercial bank. Social benefit estimates associated with CAE indicate that they helped generate social added value 4.5 times higher than FONTAR's contribution. The fiscal return was positive, because it fostered a cumulative amount of revenue that was 4.5 times higher than the fiscal cost of the contribution. Furthermore, the social added value grew by 30 % compared to what it would have been achieved without the CAE, with a positive balance in the equation between social benefits and costs of the instrument.

The PI-TEC has increased and improved the public instruments menu to promote innovation and competitiveness. By now, the pace of implementation has been uneven but satisfactory in terms of the goals set at the beginning of the PMT III. The difficulties are due to the complexity of formulating plans to improve competitiveness in an associative dynamic based on actions to be developed according to a cumulative sequence during a midterm period. The call to PITEC, tasks for formulating plans, and applications for supporting defined actions accounted for the limited entrepreneurial skills to develop such initiatives. Consequently, when designing the PITEC, it must be assumed that collective actions are not coordinated spontaneously and planning capacity must be assisted explicitly. Furthermore, strengthening of UVT and other agents capable of coordination within production clusters as well as FONTAR teams is recommended to be considered. This experience accounts for major institutional learning that should be capitalized and deepened.

The beneficiary institutions indicated that ARAI helped improve services already offered and they also helped to develop new offers. This resulted in higher revenues for services, and in some cases, laboratories and technical institutes have become focal points in their field nationally and internationally. Beneficiaries acknowledge that without the ARAI, many activities would not have been carried out.

Among its strengths, it should be emphasized that FONTAR has successfully run instruments funded by the PMT III in due time and manner. The selected projects were adjusted to the objectives of the program, and in this way, firms could introduce different degree of innovations in products and processes.

In turn, the analysis suggests that the program's social benefit has been positive. These are not conclusive results because tests were for a limited set of projects and there are methodological limits to extrapolate the findings to the whole. Anyway, these partial results indicate that State support for innovation projects implemented by the firms would have a positive social return: The benefits for society as a whole outperformed the monetary costs involved in the provision of subsidies and soft loans. It was also noted that state action positively changed the behavior of firms and triggered additional investments in R&D and innovation. The projects

selected by FONTAR strengthened firms increased the added value output, created skilled employment opportunities, and strengthened technological skills.

From a more aggregate perspective, FONTAR helped leverage the economy growth cycle, providing resources to increase technology-based investment. In particular, support was given to sectors with good potential to diversify the production matrix, for example, those who are producers of capital goods, software, food biotechnology, and medicine.

The analysis of FONTAR performance between 2006 and 2010 allowed the identification of some weaknesses. On the one hand, actions taken have been limited to providing financial assistance to firms. Although the initial intention was to give more prominence to the creation of intangibles and associative links, later it turned toward loans for purchasing equipment and money transfers (since it is assumed that firms in isolation know how to direct their efforts to achieve results and innovative transformations). Thus, activities with the greatest externalities potential and larger-scale initiatives were relegated. The challenge of achieving a critical mass of firms which contribute to build a production sector with competitiveness based on technological capabilities still remains present. Possibly, limitations in institutional design, the complexity of the instruments, and restrictions on resources for management explain this result.

Also, in terms of coordination, it is important to emphasize that the implementation of loans for firms allowed a joint work with commercial banks. This resulted in a new working mode which opened an effective means of contact with the firms as regards allocation of funds. In the future, the division of labor between the Agency and banks should be reviewed to encourage the transfer of evaluation skills and the selection of technology projects toward financial institutions. The latter has focused solely on accountant and economic evaluation without incorporating new skills. It will also be necessary to strengthen the prominence of the Agency for firms to know the origin of the funds and the objectives that are granted (issues which bank mediation could dull). Furthermore, the Agency established the link with the ad hoc partnerships and strengthened the relationship with some UVTs. The development of integrated projects was a coordinated working experience which proved that the development of more complex projects requires specialized agents that may reconcile the interest of several firms and, at the same time, plan a greater scope and sophisticated sequence of actions. Certainly, the support necessary for the emergence and consolidation of such agents has been reduced. No substantial changes in the dynamic of the relationships between scientific institutions and firms can be attributed to PMT III although it should be noted that these links are not as scarce or as weak as it has been stated many times.

5.5 Evaluation of the Impact of FONCYT Instruments

One of the most important expectations in financing competitive R&D is that the subsidy is reflected in an increased productivity for beneficiaries. To verify this, a kind of counterfactual experiment was suggested in which a group of funded

researchers was compared to a control group. Thus, PICT resulted in an increase of 35 % in the number of publications with respect to the control group. Furthermore, when considering age and doctoral level, the effect was even greater: The new beneficiaries of PICT had about one publication more than non-beneficiaries. The econometric results also suggested that PICT beneficiary publications produced higher quality (highest impact) compared to the control group.

For the first time, a counterfactual analysis performed on the quantity and quality of patents generated, presenting evidence about the positive impact of PICT, was conducted. Additionally, the PICT represents a quality certificate within the National Innovation System, setting a quality threshold, which is associated with well-defined interests from main stream and the group's history of R&D. The PICT is the main source of funding for research and a key tool in recruiting and consolidating groups with high territorial and disciplinary concentration.

Regarding the importance of PICT, in 2012, a study[7] on the application and transfer of advances generated in these projects was carried out. To this end, an evaluation of the potential applicability of PICT results by combining various approaches and information sources (final reports of projects, survey data processing, processing of information available in patent databases and case studies). This work shows that around 45 % of the projects have been the framework for patent applications or significant technology transfer to the social and productive sectors.

The PICTO proved to be a tool for promoting research with good distribution regarding territory, compared to PICT. However, beneficiaries are less productive and have higher domestic anchoring and lower international competitiveness than PICTO beneficiaries. At the organizational and academic level, PICTO has affected beneficiary institutions as it has facilitated human resources training (reversing the flow of new researchers to other national universities). It has also allowed for equipment acquisition, generated a flow of funding, improved academic offerings (new courses, specializations, and postgraduate and doctoral studies), and has boosted external cooperation (national and international) among institutions. The PICTO has had structural effects for R&D groups, because the subsidy endowed researchers with competitiveness to obtain a PICT subsidy, contributing to the development of microterritories of excellence (some laboratories).

PID is a tool that allowed researchers to bring their own projects to potential adopters, with incidence in the territory when the adopter is a public body such as a municipality. An assessment of projects for companies could not be carried out because results coming from analyzed projects could not show any trend.

HRP speeds up the return process of those researchers who had planned their return to the country with effect on the development of new lines of research. It is an instrument that was taken by institutions with different uses and meanings according to their interests and abilities, being a highly complex instrument for management and impact on the different dimensions that regulate R&D activities.

[7] Report "Potencial de aplicabilidad y transferencia de los PICT." Porta and Codner (2012). Mimeo.

The PME meant interrupting a process of disinvestment in equipment, covering also strategic and vacancy areas and with an impact on the recruitment of new human resources. PME followed a pattern of territorial concentration of PICT. However, it was an instrument that has had an impact on regional and territorial integration of knowledge and disciplines through cooperation between research groups. The PME had a positive impact on cooperation activities with national and local public sector, although the link rate with firms is lower.

PRAMIN followed the PICT concentration pattern, being used by institutions with different objectives, depending on their needs. Institutions used it to make small-scale improvements, mainly oriented to workspaces, such as the redistribution of unused spaces and, to a much lesser proportion, for technological improvements that allow a qualitative leap in the workspaces. In general, the focus was on expanding building capacity, through the transformation of spaces, or building new facilities, showing the need to increase the area devoted to R&D within the institution.

PAE was a complex management tool. It was imperative for the consolidation of networks of public–public or public–private partnership. Among the impacts caused by the PAE, the inclusion of non-traditional agents in R&D outstands, such as the case of agencies responsible for regulation and registration of pharmaceuticals. PAE synergized scientific and financial cooperation for purchasing equipment, training professionals in interdisciplinary areas, and addressing complex problems with higher requirements.

Generally speaking, instruments managed by the ANPCYT met its objectives, generating the expected impacts. In addition, the high level of execution on almost all instruments and the overall achievement of the targets set in the logical framework for the number of projects to be funded throw light on the important implementation capacity of the ANPCYT, this being a strength which distinguishes it within the field of public administration. However, it was identified by its weaknesses regarding its skills to manage project information and little experience in the evaluation and monitoring based on indicators. There were also problems associated with the complexity of the procedures for disbursement and stiffness in the limits established to reward human resources in R&D. Therefore, it is recommended to seek mechanisms that, by integrating proper guarantees, grant down payments of subsidies passed to facilitate project implementation and to put specific time limits for its duration.

Partnership projects presented new and complex problems for management, representing new challenges to be solved while improving the sophistication of instruments.

From the results of PMT III evaluation, it can be asserted that the overall program objectives have been accomplished, strengthening scientific and technological capabilities of the country and increasing the competitiveness of the productive sector through knowledge and technology production and incorporation. That is, PMT III implementation has contributed to the development and strengthening of the National Innovation System as well as Regional Innovation Systems.

6 Reflections on STI Policy in Argentina

The evaluation carried out shows that the implementation of the PMT III reached the agreed aims. Both calls and application of the instruments were implemented within suitable terms to meet the overall working plan. The capacity of selection and evaluation of the Agency and its relationship with the scientific community as well as with technology transfer and linking institutions were strengthened. These results are closely connected to the achievements of previous programs, providing continuity to prominent national state action in the promotion of scientific research and technological innovation. The acceleration of inflation partly altered the incentive scheme planned in the program design and showed the difficulties faced by these multiannual programs as regards their performance in a context change. There were minor advances in information management associated with project development; further progress is needed in the implementation of a system of indicators to facilitate monitoring tasks, allowing a more strategic and comprehensive management of the program, and substantiate an impact evaluation of the actions taken.

The profile of the beneficiaries and the results obtained by the application of promotion instruments were adjusted to the guidelines provided by the program. Participating firms used state support for activities aimed at achieving product or process innovations and production capacity increase. In this attempt, they strengthened their technological skills and, to a lesser extent, their links with the rest of the actors who constitute the productive and scientific sector. Research teams who accessed the various instruments offered have improved both performance and results. Resources used to improve infrastructure and equipment allowed universities to modernize facilities and research institutions after decades of budget shortfalls.

There were major difficulties in implementing instruments to facilitate the development of intangible assets by firms. There were also significant limitations to promote partnership schemes between firms and, to a lesser extent, between governmental and scientific institutions. Besides the need to improve incentive schemes to achieve effort alignment and access to the results, it was also important to promote projects which enhance more directly and explicitly investment processes for production chains that alter the pillars on which competitiveness is based. From this experience, the way to solve social deprivation is to design projects through the support and participation of local and sectoral bodies outstand. On the whole, associative instruments have enriched and sophisticated public sector promotion instruments menu; its implementation represented institutional learning that must be capitalized and deepened.

The finding of the positive impact of PMT III calls for a more general reflection on the need to better articulate these policies to promote scientific research and technological innovation into a strategy and development program which will coordinate, rationalize, and enhance the different public instruments available. The relatively isolated execution of resources allocated to PMT III reflects the difficulties in changing some of the central tenets of the scientific and business structure.

Most of the research grants replicated patterns of geographical and disciplinary concentration characteristic of the Argentinean scientific system. In terms of technological innovation, transfers made through grants or loans aim at a group of firms that fail to establish a critical mass able to significantly alter the sources of competitiveness featured by Argentinean industry.

At present, the development agenda is being discussed in Latin American countries, all of which face the challenge of social inclusion, inequality reduction, and environmental sustainability in a context of volatile global economy characterized largely by predatory forms of competition. As part of the requirements of a development strategy aimed at fulfilling these objectives, the countries of the region—beyond the diversity and heterogeneity of their production structures—share the need to strengthen the institutions devoted to scientific and technological development and to improve the efficacy of those policies promoting training of highly qualified resources, research development, knowledge transfer to the productive system and the consolidation of behaviors and practices for innovation generation and diffusion. Overall, in recent years, most countries have implemented similar approaches to STI policies with different results.

As regards regional comparison, Argentina has a relatively high degree of diversification of its production structure. In the national productive sector, the important role of the agro-food chain, the relevance of a group of high heterogeneity industrial production, and the presence of a number of technology-based activities stand out. In recent years, the high dynamism of Argentinean economy helped reverse the trend of production deindustrialization, primarization, and downsizing. Despite this, and even in a context of a significant expansion process, the national productive sector failed to reverse one of its most salient features: its technological backwardness and dependence.

Thus, leading productive activities are characterized by a high degree of concentration and for occupying less dynamic segments as regards technology of several production chains. The exception to this trend was a reduced set of more virtuoso performance activities such as agricultural machinery manufacturing, pharmaceutical production, and computing services, which despite not being at the international forefront display a behavior that distinguishes them from the rest. In this way, opportunities created by a group of long-standing activities in the country are highlighted, which become a field of possibilities for the development of productive and technological policy.

As regards promotion policy issues, the country has an outstanding history even in a context characterized by ups and downs in public intervention approach and relevance. This history resulted in a heterogeneous and unstructured policy system. Consequently, in this context and despite some recent efforts to reverse the existing shortcomings in financing, the promotion system is characterized by the dominance of fiscal instruments, effort duplication in some areas, and the existence of voids in important production segments.

Meanwhile, the scientific and technological Argentinean systems stand out in the region by its large reserves of highly qualified human resources, as well as by the existence of a number of institutions with long experience in research and

technology transfer to the agricultural productive sector, such as INTA; in nuclear technology research and development, such as CNEA; and in satellite technology, such as CONAE. Despite this, and the significant efforts made in recent years, the national STI system displays relatively low spending levels and little private investment in these activities in an international comparison. In this context, FONTAR tasks stand out, which in recent years emerged as one of the leading institutions promoting productive innovation, thanks to increasing its budget and diversifying its instruments.

Despite recent efforts, the overall scope of STI promotion institutions in Argentina still seems insufficient to pull the private sector investment and to promote greater coordination between system agents. Thus, it seems relevant to foster greater intervention to enhance larger productive segments of technological dynamism in order to achieve not only a productive leap which provides sustainability to the economic growth process, but also which promotes increased participation in those more skilled and better-paid activities. Therefore, although the country has a production sector of certain density and complexity, the need for instruments and policies to ensure a process of productive change will improve the living conditions of the population and overcome barriers to growth which have historically affected Argentinean economy.

References

Afcha Chávez S (2011) El impacto de los subsidios a la I+D en la empresa: Evidencia empírica sobre enfoques alternativos de evaluación. Revista Iberoamericana de Ciencia, Tecnología y Sociedad CTS 17(6)

Arora A, Gambardella A (1998) The Impact of NSF Support for Basic Research in Economics. Cited in Chudnovsky et al (2006b)

Bisang R (1995) Libremercado, intervenciones estatales e instituciones de Ciencia y Técnica. Revista Redes 3

Cárdenas E et al (2000) La industrialización y el Estado en América Latina: los años de la postguerra. FCE, Mexico

Carullo J et al (2003) Programa de consejerías tecnológicas. Evaluación y recomendaciones. Informe final. Paper written for the Secretary of Science, Technology and Productive Innovation. Centro Redes, Buenos Aires

Chudnovsky D et al (2006a) Evaluating a Program of Public Funding of Private Innovation Activities. An Economic Study of FONTAR in Argentina. Office of Evaluation and Oversight (OVE)—IDB, Washington DC

Chudnovsky D et al (2006b) Evaluating a program of public funding of scientific activity. A case study of FONCYT in Argentina. Office of Evaluation and Oversight (OVE)—IDB, Washington DC

Cimoli M et al (2009) Science, technology and innovation policies in global open economies. The Case of Latin America and the Caribbean. Revista Globalización, Competitividad y Gobernabilidad 3(1)

Codner D (2005) Evaluación de impacto de instrumentos de promoción de la ciencia y la tecnología del FONCYT

Crespi G, Geuna A (2004) The Productivity of Science. SPRU Report prepared for the Office of Science and Technology (OST) of the Department of Trade and Industry (DTI), UK. Cited in Chudnovsky et al (2006b)

Crespi G, Geuna A (2005) Modeling and Measuring Scientific Production: Results for a Panel of OECD Countries. SPRU Electronic Working Paper Series 133. Cited in Chudnovsky et al (2006b)

Dosi G et al (1988) Technical Change and Economic Theory. Pinter, London

Loria Díaz E (ed) (2001) Viejos y nuevos dilemas de las revistas académicas mexicanas. Universidad Autónoma del Estado de México, Mexico

Georghiou L (2002) Impact and Additionality of Innovation Policy. In: Boekholt P (ed) Innovation Policy and Sustainable Development: Can Innovation Incentives Make a Difference? IWT Observatory, Brussels. Cited in Afcha Chávez S (2011)

Georghiou L (2004) Evaluation of Behavioural Additionality. Concept Paper. Making the Difference—The Evaluation of Behavioural Additionality of R&D Subsidies. IWT Studies 48:7–20. Cited in Afcha Chávez S (2011)

Goldfarb B (2001) The Effect of Government Contracting on Academic Research: an Empirical Analysis of Reputation in Research Procurement. Discussion Paper No 00-24, Stanford Institute for Economic Policy Research. Cited in Chudnovsky et al (2006b)

López A (2009) Las evaluaciones de programas públicos de apoyo al fomento y desarrollo de la tecnología y la innovación en el sector productivo en América Latina—Una revisión crítica. Regional Dialogue on Innovation, Science and Technology. IDB, Washington DC

Lugones G et al (2005) Potencialidades y limitaciones de los procesos de innovación en Argentina. Working paper 26. Centro Redes, Buenos Aires

Lundvall B-A (2009) Sistemas nacionales de innovación. Hacia una teoría de la innovación y el aprendizaje por interacción. UNSAM, Buenos Aires

Nelson R, Rosenberg N (1993) National Innovation Systems. Oxford University Press, New York

OECD (2005) Behavioural Additionality or R&D Grants: Introduction and Synthesis. OECD, Paris

OECD (2006) Government R&D funding and firm behaviour: measuring behavioural additionality. OECD, Paris

Peirano F, Gutti P (2007) Una propuesta metodológica para la evaluación de impacto de las políticas de ciencia, tecnología e innovación. Paper presented at the XII Seminario Latino-Iberoamericano de Gestión Tecnológica, ALTEC, Buenos Aires

Porta F, Lugones G (eds) (2011) Investigación Científica e Innovación Tecnológica en Argentina. Impacto de los fondos de promoción. BIG-MINCYT/Universidad Nacional de Quilmes, Buenos Aires

Porta F et al (2010) Políticas de ciencia, tecnología e innovación en Argentina. Evolución reciente y balance

RICYT (2010) El Estado de la Ciencia. Principales Indicadores de Ciencia y Tecnología Iberoamericanos/ Interamericanos. Buenos Aires

Sanz-Menéndez L (1997) Science and Technology Policy Evaluation in the Context of Advanced S&T Policy Planning. Working Paper 97-03. CSIC, Madrid

Sarewitz D (2010) Advancing the Science of Science and Innovation Policy. CSPO Report #10-04. Consortium for Science, Policy and Outcomes (Arizona State University), Phoenix

Stokes D (1997) Pasteur's Quadrant: Basic science and technology innovation. Brooking Institution Press, Washington DC

Innovation, Production and Innovation Systems and the BNDES' Contribution

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Abstract This chapter summarizes the debate regarding further understanding concerning the concept of innovation, focusing on one of its most important developments: innovation and production systems and arrangements. Its central aim was to discuss the results for the purpose of adjusting current policies implemented in Brazil and, hopefully, throughout Latin America. It presents the BNDES' experience involved in providing support for innovation, regional development and local innovation and production systems (LIPS), whilst addressing the main implications of policies that arise from the debate.

1 Stylized Facts: Advances in Understanding Innovation[1]

Theoretical and empirical studies mostly carried out during the last two decades of the twentieth century have generated a significant accumulation of knowledge related to innovation. This has led to fundamental advances concerning the understanding of innovation, as well as in the design of policies for its promotion. Among the main improvements is the fact that from the 1980s onwards, the focus has shifted from individual innovations and now focuses on systemic processes for generating, acquiring and using new knowledge. Innovation is no longer seen as an external element ('manna from heaven') or an isolated action, but rather as a cumulative process, which is not linear, but rather systemic with multiple and simultaneous origins, resulting from interaction between different agents. Also, a broader understanding of

[1] This part is based on Lastres and Cassiolato (2011).

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technical progress and modifications linked to institutional and organizational activities has shed new light on the need for policies to foster this aspect.

Significant advances have originated from the distinction that has been made between information and knowledge. Notably, the notion of innovation has greatly benefited from the promotion of views contrary to neoclassical theory that considered information and knowledge to be synonymous; and considered technology to be an external factor and a quasi-product that could be sold, transferred, etc. Besides merely distinguishing information from knowledge, two other differentiations have been emphasized. Firstly, it is important to recognize the difference between tacit and codified knowledge. The latter, transformed into information, can in fact be reproduced, stored, transferred, acquired, sold, etc. However, transforming tacit knowledge into signals and codes and their consequent transmission represents extremely difficult tasks, because of the required learning processes, which depend entirely on contexts and specific forms of social interaction (Polanyi 1966). Secondly, there is the distinction between invention and innovation, where successful research and development (R&D) activities can result in inventions. However, inventions, no matter how important, will not necessarily be transformed into innovations.[2]

Moving forward with these ideas, from the end of the 1970s, the understanding of innovation in particular has grown. Prior to this, innovation was seen as something that took place in stages and was related to basic research, applied research, development, production and dissemination (a linear view of innovation). Generally, discussion concerning the sources of innovation was divided between those that attributed more importance to advancing scientific development (the so-called 'science push') and those that emphasized the impact of pressure related to demand for new technology (or the 'demand pull').

Studies carried out by Mowery and Rosenberg (1979) and others clearly expose the trap of separating two aspects that are now recognized as forming part of the same process and considering them as opposites and alternatives. The common, restricted and dichotomist viewpoint that set apart the impulses arising from supply or demand for knowledge (*science push vs. demand pull*) has been demystified definitively. From this time, the understanding of innovation has been consolidated no longer as a momentary, isolated and independent action, but rather as a non-linear process capable of involving, even simultaneously, knowledge that resulted both from the accumulated in-house experience and from the interaction between all types of organizations. Apart from this, there is an implicit understanding that important parts of production and innovation capacity are equally tacit but are derived from learning processes, which involve doing, producing, using and interacting, rather than only from research processes related to science and technology. Hence, the conclusion that innovation is much more than R&D.[3]

[2] One of the classic contributions in innovation literature discusses why some inventions are quickly transformed into innovation, while others take years and even centuries, and others never leave the drawing board (Jewkes et al. 1958).

[3] The phrase "innovation is much more than R&D" was coined by Harvey Brooks in the 1980s, explaining the idea that R&D is only one of the possible sources of information for the innovation process.

Here, we present a number of conclusions that relate to the emphasis applied to understanding the distinct conditions offered by the local and national context where innovation processes are carried out;

- The main attributes of innovation success stories involve connections to diverse sources of information, both internal—that include R&D, production, marketing, commercialization, training, hiring human resources—and external to the firm—ranging from relations traditionally deemed crucial among companies and research and teaching institutions to those relations between competing companies or those in the same production sector or complex.
- Reverse engineering is a prominent means used by most companies to appropriate knowledge, reinforcing the relevance of dialogue and the flow of knowledge between the production and innovation agents in the same production system.
- Accumulating internal capacity in companies has proven fundamental to innovation as it enables the enhancement of processes, concerning interaction with the external context and, especially in terms of understanding, assimilating and using knowledge brought in from an outside source.
- There is a significant complementary level comprising radical and incremental innovation, technical and organizational innovation and their distinct and simultaneous sources.

Acknowledgment of the systemic nature of innovation gained ground in the 1980s: the 'coupling mechanisms' between the education system, scientific institutions, R&D facilities, production and markets have comprised an important aspect of institutional changes introduced among successful national innovation systems (Freeman 1982). This contribution—which also recognizes the fundamental influence of financial systems, education and organization of work concerning technological decisions and strategies—was a clear sign that the concept of a national innovation system had been defined and was in use (Freeman 1987).

Notably—as several Latin-American and Caribbean authors have commented, since the 1960s and 1970s—the systemic view expanded the understanding of technological and industrial dynamics and the possibilities of policies for implementation. This view implied acknowledging and operating within the conditioning factors of the specific macroeconomic, political, institutional and financial context in different countries, as well as the role of each country within the world system (Furtado 1961, 1998).[4] Fundamental emphasis was even given to the observation that this macro-context represents 'implicit policy', which is capable of annulling specific and explicit policies (Herrera 1971).

Coutinho, Erber, Sagasti and Katz are examples of authors who promoted this discussion in the context of the 1980s and 1990s in Latin-American countries. They indicate how the exchange rate and interest rate policies, far from being neutral, directly impact microeconomic planning and consequently investment strategies. They also point out that economies subject to high interest rates penalize their

[4] For a discussion outlining the similarities between the Latin-American Structuralist School of thought and Schumpeterian's line of reasoning, see Cassiolato et al. (2005).

national companies, conditioning and determining decisions that establish standards for financing, corporate governance, foreign trade, competition and technical change. Coutinho (2003) established this understanding, comparing the performance of companies operating in 'malignant and benign macroeconomic regimes'. **Hence, the importance of development strategies that mutually reinforce dialogue between macroeconomic policies and technological and industrial policies, as well as the recommendation that this dialogue is aimed at sustaining, both exporting efforts and the substitution of imports, as well as thwarting disloyal imports, dumping and discriminatory barriers against national production; likewise, this dialogue should aim to aggregate value to these products and instigate local learning processes**. Katz (2008) recalls that the relation between the behaviour of macroeconomic variables and the dynamics of the innovation and production systems constitutes a chapter of economic theory, still to be written and better developed.

Another important aspect is an improved understanding of how innovation and diffusion of innovation are jointly and simultaneously defined. In this mutual and symbiotic relationship, the context where innovation is developed and disseminated establishes the technological evolutionary pattern, which in turn, redefines the path of innovation. Different contexts are associated with varying standards of technological progress. This conclusion emphasizes the national, regional and local specificities of generating, using and disseminating innovations. The view of innovation as a non-linear, cumulative, systemic, context-specific process is reaffirmed. This perception has also reinforced the need to demystify simplistic ideas concerning possibilities for buying, copying, transferring, assimilating and applying technologies.

From this point of view, innovation systems are understood as groups of institutions and their interrelationships that affect capacity to learn and create and, most importantly, for employing national and local competence. These systems contain not only organizations directly focused on STI, but also mainly all those that directly or indirectly affect the actions and innovative capacity of the agents. A direct after-effect of this understanding is that, for example, the financial sector and the policies—including the broader macroeconomic policies—became one of the main concerns of policy makers.

Therefore, the basic concept pertaining to innovation systems is that its performance depends not only on companies, teaching and research organizations, but, for the most part on the way, they interact with each other and with other agents. Besides this, it also depends on the context that they form part of, including the macro-cultural, institutional and policy frameworks. This, therefore, corroborates the argument that innovation processes at a company level are generated and sustained by their relations with other organizations, reflecting the characteristics of local and national production and the innovation systems they pertain to.

Taking this approach helps strengthen understanding of the role played by historical processes, institutional and policy evolution, socio-economic conditions and capacities, etc.—that are responsible for differences in national and local development paths.

The relevance considering the specificities of each agent, the quality of their interactions and the functions of institutions was generally reaffirmed, whilst taking

into account informal and formal norms and rules. With this, distinct contexts, cognitive and regulatory systems, as well as formal and informal methods for dialogue and learning are deemed fundamental for explaining the differences in acquiring, using and disseminating knowledge, especially tacit knowledge.[5]

Of course, there are differences between strictly sectorial viewpoints concerning innovation and the systemic approach presented here. The first important difference refers to the fact that the sectorial point of view tends to homogenize the guiding principles of analytical and policy efforts overlooking historical and territorial paths of different spaces where innovation and production activities take place. Secondly, it is important to note that what is summarized as policy sectorial requirements usually embody the demands of the most influential groups, whilst ignoring the needs of other agents—especially SMEs—that certainly deserve support from government policies. A third point relates to the analytical and policy limitations when focusing solely on certain areas of innovation and production systems whilst missing the opportunity to capture their entire structure and dynamics: from the input of production up to final consumption. Here, it is important to emphasize the possibilities that are offered taking a broader view of sociocultural and economic environment and the knowledge base required to enable the very existence and evolution of different production and innovation systems. Fourthly in this discussion, it is impossible to ignore the problem of sector borders constantly undergoing change. Questions are raised concerning traditional forms of measuring and assessing economic activities that group them in sectors, in light of the enormous heterogeneity of the distinct innovation and production structures present in the same sector. Likewise, there is a tendency to incorporate increasingly multidisciplinary knowledge, whilst also merging technological functions and devices from several sectors and areas, until now disconnected. There are emblematic examples in the so-called primary sectors, such as agriculture, extraction and fishing, as well as in the more complex production areas.[6]

Fishing, for example, makes use of: design and advanced materials for ships and fishing equipment; communication and satellite for tracking systems; sonar systems, sensors and optical identification to monitor schools and selections of fish; online systems for weighing, assessing, cooling and air-conditioning, as well as for monitoring activities. This is also true in the case of fish farms, which have been incorporating advanced design and materials when building lakes, reservoirs, etc.; nutrition, medication and reproduction technologies based on biotechnology, genetic and robotic engineering. Besides this, there have been efforts to develop and employ equipment, systems and procedures aimed at protecting the environment and guaranteeing sustainability in production.

With extensive dissemination of new technologies—that are the basis for intensive production standards in information and communication technologies (ICTs), biotechnology, genetic engineering and advanced materials—even sectors

[5] For details see for instance Jonhson and Lundvall (2003).

[6] For details see also Perez (2010).

considered traditional can claim that they make intensive use of state-of-the-art technologies. The inappropriate way economic sectors are defined, therefore, becomes even more evident. The usual sectorial classification is related to areas of knowledge and activities that may represent a minority part in the aggregate value of the sector in question. Emphasis is then placed on the imperative need for a revision concerning the use of this approach, aiming both to cope with these challenges, whilst also permitting the use of more advanced and complete understanding of innovation and production dynamics. An unrelated example is the need to design and implement policies encompassing specific requirements for distinct production activities and their local systems and arrangements.

2 Analysis of the Brazilian Experience in Developing and Using the Concept of Innovation and Production Systems

In Brazil, the concept of local innovation and production systems (LIPSs) was created and developed by RedeSist in 1997 and was rapidly disseminated throughout teaching and research areas, as well as in the context of policy. This concept combines contribution concerning the development of the Latin-American structuralist school of thought and the neo-Schumpeterian viewpoint concerning innovation systems.[7] Attention is given to the significant learning process that was activated when this new approach was put into practice, both as an analytical tool and a guide for policy. All agents involved learned extensively from their hits and misses.

The LIPSs approach encompasses a range of economic, political and social agents, and also their interactions, including: companies that produce goods and services as well as suppliers of raw materials, equipment and other inputs; distributors and retailers; workers and consumers; organizations working with education and training in areas such as human resources, information, research, development and engineering; support, regulation and financing; cooperatives, associations, unions and other representative organizations. Following its source of inspiration, this approach emphasizes that innovation and production dynamics present space and time differences, reflecting local conditions and capacities involved in assimilating and using knowledge and requiring specific policy support.

The main focus is on the agents of the different LIPSs, the activities they perform, the interactions between them and the specificities of the territory where they operate. From this point of view, the production of any good or service will always involve the engagement of a system that involves related activities and agents ranging from the acquisition of raw materials, machinery and other inputs for production. These systems vary from the most rudimentary to the most complex and articulated forms. An important argument related to this refers to

[7] For details, see (Cassiolato and Lastres 1999; Cassiolato et al. 2005; Guimarães et al. 2006 and www.redesist.ie.ufrj.br).

the importance of using this approach as a focusing device. On the one hand, it promotes better understanding of any production and innovation structure and dynamics. On the other, it provides a very useful tool for orienting policies for the mobilization of production and innovation capacities.

Here, it is important to point out the relevance of using analytical lenses and policy models that do not limit the selection of cases eligible for support. Attention is given to the fact that certain indicators and methodologies encapsulate political decisions. LIPSs that are selected for governmental support should reflect the main goal inherent in national and regional development strategy. It is not possible for this selection to result from policy models that are restricted or limited in terms of access.

Likewise, it is noteworthy that throughout the world in the 1980s and 1990s, sectorial typologies and indicators were developed with the aim of understanding processes involved in learning, capacity-building and innovation. Nevertheless, most of these efforts imply a strong reductionist tendency, requiring attention. The analysis of the Brazilian experience reinforces the argument that history and specific territorial conditions are essential for explaining how production and innovation capabilities are acquired, used and developed. Within the same sector, one can find very different production and innovation structures and dynamics requiring entirely different policy support. Analytical models, taxonomies and policy prescriptions that disregard these parameters put their usefulness at serious risk (Lastres and Cassiolato 2005).

This same argument has been forcefully put forward by a number of authors, including Schumpeter (1939), as Freeman recalls when he quotes him as stating; general history (social, political and cultural), economic history and industrial history are not only indispensable, but are really the most important contributors for understanding our problem. All other statistical and theoretical materials and methods are in fact subservient to these and worthless without them (Freeman 1982). Lundvall (1985) has also reinforced this point by emphasizing that to develop a general theory of innovation system that abstracts from time and space would undermine the utility of the concept, both as an analytical tool and as a policy tool.

Therefore, it is not sufficient to develop indicators and maps aimed at quantifying existing systems, their different structures and levels of development. Also, the use of such classifications, indicators, and the selection of exemplary cases should under no circumstances inhibit understanding of the differentiated elements that enrich experiences present in the real world. This point is particularly important when defining and implementing policies. Here, emphasis is given, to the conclusion that the use of uniform and de-contextualized policy models ignores the existence of disparities, due not only to sectorial and other economic factors, but also to diverse sociopolitical frameworks and to historical and geographical particularities (Furtado 1998).

Together with these developments, ideas that acknowledged supranational and sub-national systems (Freeman 1999) as well as local innovation and production systems—LIPSs (Cassiolato and Lastres 1999) were proposed. Focus was oriented towards LIPSs aimed at meeting the imperative need to fulfil the potential of policy efforts, redirecting them to the territory and to interaction between the many agents.

The purpose of this was to stimulate capacity-building, learning, innovation and competitiveness in order to expand and establish local development.

This approach is directed towards a new way of perceiving, thinking and implementing policy that encompasses agents and innovation and production activities, with their distinct paths and dynamics, ranging from those that are more knowledge intensive to those that employ endogenous or traditional knowledge, of different capacity and function, stemming from the primary, secondary and third sector, operating locally, nationally or internationally.

2.1 The Brazilian Development Bank's Operations

The National Bank for Economic and Social Development (BNDES), created in 1952, is a state-owned company and the main funding supplier for long-term investments in all sectors of the economy. This bank is extraordinary for financing production projects and enterprises, as well as infrastructure, including public services including education and health systems, sewage and water treatment and urban transport. In addition to major projects, BNDES finances micro and small enterprises operating in different areas, including family farms. Its total assets reached US$369.7 billion in 2011, with a distribution of US$82.7 billion in the same year, qualifying BNDES as one of the three largest development banks (DB) in the world (Table 1).

In 2012, its assets were worth a total of US$347.3 billion with a distribution of US$75.7 billion[8]; 35 % being allocated to infrastructure investments, 31 % to industry, 28 % to commerce and services and 7 % to agriculture, and in terms of business; 23 % was loaned to micro and small enterprises. Accumulated knowledge concerning the dynamics of Brazilian development, derived from its wide range of operations, qualifies BNDES as a significant contributor in terms of helping design federal government policies. This concerns mainly infrastructure, production and innovation, as well as socio-environmental dimensions of development often in association with the Ministry of Industry and Trade, to which it is linked.

All over the world, DB have formed an important government instrument providing long-term loans to finance economic and social development. During the global financial crisis of 2008–2010, most DBs played a crucial countercyclical role by providing credit that was not available from private commercial banks or capital markets for both private and public agents. In Brazil, BNDES played a crucial role,—responsible for 37 % of the increase in credit from Sep/08 to Sep/09—together with that from other federal banks as presented in Fig. 1.

[8] The small decline here in comparison with 2011 is due to currency devaluation. In real terms, there was an increase of 11 % in the total amount disbursed from 2011 to 2012. It is important to note that in first two months of 2013, BNDES disbursement has increased by almost 40 % compared with the same period in 2012.

Table 1 BNDES and other multilateral banks

US$ millions	BNDES	IDB	IBRD	CAF	China DB
	Dec 31st, 2011	Jun 30th, 2011	Jun 30th, 2011	Dec 31st, 2011	Dec 31st, 2010
Total assets	369.720	89.432	312.848	21.535	774.180
Shareholders' equity	36.102	19.794	38.679	6.351	60.953
Net income	5.354	20	930	152	5.618
Loan disbursements	82.676	8.400	21.839	7.694	86.690
Capitalization (%)	9.76	22,13	12.36	29.49	7.90
ROA (%)	1.65	0,02	0.30	0.71	0.80
ROE (%)	23.12	0.10	2.40	2.39	9.50
Established	1952	1959	1945	1968	1994

IDB Inter-American Development Bank
IBRD International Bank for Reconstruction and Development (World Bank)
Unlike other institutions, 12-month fiscal year ends June 30th
CAF Latin American Development Bank
CDB China Development Bank
Capitalization Shareholder's equity/ total assets
ROA Return on average assets
ROE Return on average equity

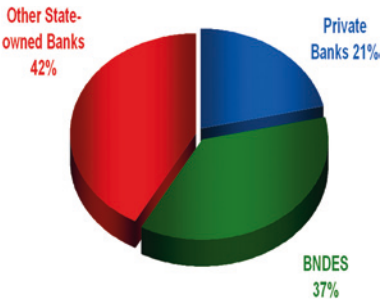

Fig. 1 Brazilian official banks sustained credit after the crisis: contribution to credit growth (Sep/08–Sep/09). *Source* Central Bank of Brazil

The experience of the Brazilian development bank (BNDES) also shows the implementation of policies that contribute to expanding conditions for development, in terms of improving regional distribution of production activities and to alleviating other inequalities. Coutinho (2008)[9] states that the end of the first decade in the millennium is characterized by a need to re-assess the bases for development, pointing out that the strategy must include the design of new policies that foster Brazilian production and innovation potential in all its diversity. To meet the challenges inherent in cohesive, dynamic and sustainable development established by Brazil's federal government, the author emphasizes the need for new policies capable of identifying priorities and fostering potential related to local and regional development. He also stresses that (i) to implement such policies requires systemic treatment of production activities; and that (ii) connection to territories

[9] Luciano Coutinho, the president of BNDES since 2007, is also a professor and specialist in production and innovation development and international economics.

offers a valuable opportunity for expanding and establishing development. Emphasis is, therefore, placed on fostering interactions among companies and other agents to reinforce capacity-building processes, as well as local and sub-regional innovation and production performance, by means of policies aimed at a range of agents, their interactions and their territories.

Another related challenge refers to the aim to reinforce policies that stimulate the incorporation of knowledge and innovation in Brazil's different regions and productive activities, ranging from those performed by large- and medium-sized companies to micro and small companies, cooperatives and guilds. Other challenges include efforts to change established operational and cultural paradigms, to develop new financing modalities and to coordinate efforts with partners in different areas of the BNDES and also at regional, national, state and municipal levels.

Since its creation, similar to many organizations all over the world, the organizational structure of BNDES has emphasized the sectorial approach. In order to stimulate a systemic approach, joint action and interaction between operational units and the discussion of new policies for strategic issues have been promoted; in 2007, BNDES created: a Committee for Production Systems comprising, innovation, regional, social and environmental development and a Secretariat for LIPSs and regional development at the Presidential Office. Both intend to promote better communication and articulation for these issues, not only within BNDES but also with other institutions, helping operational areas to work together; to propose new policies that promote production and innovation structures, as well as regional and local development and to contribute to incorporating a systemic vision, giving priority to territorial development.

Concerning organizational reforms, in 2008, BNDES acknowledged the importance of environmental issues and created a unit to deal with this priority. Particular emphasis was given to the Amazon region, with the simultaneous creation of a specific fund. The Amazon Fund depends on international and Brazilian donations and is mainly focused on preventing and combating deforestation by offering non-reimbursable financial support to initiatives and undertakings that are capable of making use of the forest in a sustainable fashion. BNDES manages this fund and is responsible for selecting and promoting projects with appropriate investment that prioritize alternatives guaranteeing environmental, economic and social sustainability. In order to contribute to the mitigation of Brazilian inequalities, BNDES also strengthened and consolidated activities carried out in regional offices and created a unit to foster family agriculture and projects for social inclusion.

BNDES has established two main approaches for integrated development in order to foster this type of operation in areas surrounding large-scale projects and in the least developed regions of the country. The first strategy reduces negative impacts normally caused by large-scale investment, whilst supporting surrounding areas in terms of creating infrastructure aimed at fundamentally expanding and establishing the impulse given to development, by stimulating local production and aggregation of value to goods and services and by fostering commitment to territorially integrated development related to large and medium-sized companies. The aim was to promote several large-scale projects that are being developed

in the country and include investments that are within the scope of the Brazilian infrastructure plan for the acceleration of growth (PAC)—such as infrastructure, energy, logistics and basic inputs in areas such as non-ferrous metals, pulp and petrochemicals—as well as those aiming to support industrial development, listed in the Greater Brazil Plan (Plano Brasil Maior). Priority is being given to projects located in the North and Northeastern regions of the country. The idea is to establish these projects as a centre for LIPSs and devise and foster local production and innovation activities that are related to these. Both the supply of raw materials, equipment and other inputs, and the establishment of new productive activities are being made possible by the anchor project.

Mobilization, planning and establishing collective aims and commitments are premises for the BNDES' operations in the areas surrounding these projects. The proposal intends that the agents involved should previously plan any efforts required for the implementation and operational stages, as well as preparing the territory for the new socio-economic and institutional circumstances. It is particularly important to include the participation of other economic, political and social agents operating in the territory, such as local governments, financial agents, teaching and research institutes, support and promotion organizations, workers, worker representatives and other organizations that form part of civil society. The aim is to put together an agenda focused on development for the territory, which guides initiatives and investments required for: territorial and environmental planning; urban, social, environmental and cultural infrastructure; modernization of public administration; education and capacity-building, involving local and regional knowledge systems; and economic development, mobilizing local potential innovation and production systems. The following key elements summarize this new way of operating, as defined at the end of 2009: stimulus to create a representative institution, responsible for defining the territorial development agenda that identifies activities to be financed by a participative financing mechanism; generally a fund.

The second strategy aims to mobilize production inclusion in the least developed parts of the country and is consolidated in the partnership with state governments by means of a line of credit created at the end of 2009 (BNDES States). The main advantage will be the stimulation of policy models that are capable of maximizing potential, whilst involving agents, activities and regions in cohesive and sustainable development projects. The goal is to reduce inequalities by intensifying efforts made by states in neglected and marginalized areas. This model seeks to foster integrated, long-term development in the territories of each Brazilian state, encouraging the participation of society in order to identify investments that engage agents, strengthen vocations, establish, intensify and expand knowledge and also augment capacity. This line of credit makes finance available for territorial and socio-environmental planning, urban infrastructure, sanitation, logistics, health, education, culture and institutional strengthening, together with innovation, production and capacity-building for entrepreneurs and LIPSs.

An initiative, which complements the partnership with states, refers to the use of a social fund (a non-reimbursable fund made up of a part of the BNDES'

operating profit) to financially support innovation and production projects in low-income regions and those less developed and less served by the public sector. This model proposes that the election of sectors by the LIPS to receive support should depend on a public selection process to be held by the state with the support of a committee made up of different organizations. The goal is to complement any financial support provided by the states with solidarity programs in order to contribute to reducing inequalities whilst generating jobs and income, and developing and intensifying regional innovation and production activities.

Also, noteworthy was permission to include BNDES card financial aid for contracts involving research, development and innovation for products and processes. The aim is to encourage micro-, small- and medium-sized companies to incorporate knowledge. For this purpose, the BNDES, supported by other organizations within the national innovation system, registered scientific and technological institutions (STIs) that are capable of offering these services, thus reinforcing ties between companies and institutions within each local innovation system. It is possible to contract technological services, such as: testing, prototyping, design, ergonomics, technical response and quality assessment of products and software. For this financing mode to be successful in a country that is of continent size with extreme diversity, the widespread distribution of suppliers of technological services that are physically and culturally close to the end-users and therefore understand the barriers and challenges present in the different local and regional innovation and production systems is essential. To meet these requirements, the BNDES offers a line of credit for innovation—known as BNDES Innovation—to finance companies that present an Innovation Investment Plan, taking into account continuous or concerted efforts towards innovation in products, processes and marketing. The line is also available for projects aimed at modernizing the production capacity to absorb the results of the R&D process. An additional strategy supporting innovation is in the direct participation of the bank in innovative companies or participation funds. Among these funds, Criatec stands out as a seed capital fund intended to capitalize micro and small innovative companies and also provide appropriate managerial support.

Several programs dedicated to developing specific innovation systems that dialogue with policy initiatives aimed at promoting Brazilian production stand out. Two main examples are Profarma, in the health context and Prosoft, which offers support for developing and using software. The same strategy for complementary support, aimed at different agents in the innovation and production systems, is used in the aeronautic sector (BNDES Pro-aeronautics), information technology related to the Brazilian Digital Television System (PROTVD), plastic (BNDES Pro-plastic) and for financing engineering in sectors such as capital goods, defence, automotives, aeronautics, aerospatial, nuclear (BNDES Pro-engineering), as well as oil and gas and shipping through (BNDES O&G). In 2011 and 2012, other initiatives were launched, jointly with the Brazilian Innovation Agency (Finep) aimed at fostering innovation production systems for sugar-based energy and chemicals (PAISS) and for oil and gas (Inova Petro). Other support modalities for innovation include non-reimbursable funds, such as (i) Funtec, aimed at

non-reimbursable support for research and development aligned with national technology development policies in strategic sectors; and (ii) Funttel, a non-reimbursable sectorial fund directed towards technological innovation, capacity-building for human resources, and incrementing competitiveness in the Brazilian telecommunications sector.

Concerning challenges related to regional development with socio-environmental sustainability, a prominent example is the previously mentioned Amazon Fund. Included in the bank's portfolio are projects that promote activities fostering sustainable use of the forest, attempting to meet the challenge of helping innovation and production systems, for example in the area of cosmetics, phyto-therapeutics, nutriaceuticals; taking advantage of local biodiversity.[10]

Finally, it is important to indicate that a number of these approaches can be used in a coordinated and mixed fashion.

3 Conclusions

3.1 Policy Implications Concerning Progress in Understanding Innovation

Significant progress in understanding innovation has proven the need to develop analytical instruments and broader and more complex policy guidelines than those offered by traditional economic theory (Freeman 1982, 1987; Lastres and Ferraz 1999). Similarly, progress in this area has brought about a new line of reasoning, influencing attitudes towards traditional forms of support and promoting the design of new policies truly capable of fostering science, technology and innovation (STI).

The first point to emphasize is the result of the distinction between invention and innovation. If the aim is to stimulate new discoveries, policies certainly must aim at mobilizing infrastructure and R&D activities, as well as intellectual property. In this context, it is apparent that some efforts may or may not result in inventions, and these in turn may or may not be incorporated by the production systems. Nevertheless, if the focus is to mobilize the innovation processes, policies should stimulate different forms of acquisition, use and dissemination of knowledge throughout the production structures of any good or service. It is apparent that important parts of innovation and production capacity-building are tacit and stem from the learning process; doing, producing, using and interacting, not only from conducting or hiring R&D activities. The main emphasis of new policies is, therefore, to strengthen capacity to assimilate and use knowledge derived from diverse internal and external sources.

[10] For further details about these programs and funds, see www.bndes.gov.br.

It is also important to emphasize that policies emphasizing R&D activities and new scientific discoveries generally focus on limited groups of agents (large companies and teaching and research institutions that are considered state-of-the-art), certain manufacturing production activities, as well as very few specific regions in the world. For progress to occur, it is crucial that innovation should not be restricted to particular sectors or radical shifts in technology carried out almost exclusively by large companies resulting from R&D efforts. The consequences of understanding innovation as a 'process through which organizations incorporate knowledge that is new to them in the production of goods and services, regardless of whether or not they are new to their local or foreign competitors' are significant.[11] This understanding will help avoid distortions, motivating policy makers to adopt a broader perspective when it comes to opportunities for learning, and innovation efforts related to all kinds of entrepreneurs and small and medium-sized enterprises operating so-called traditional activities.

Equally significant are implications concerning policies that comprehend generation of knowledge and its introduction and dissemination via the production system that require efforts and significant capacity-building, but also that innovative capacity derives from a blend of economic, social, political, institutional and cultural factors, as well as the space in which they operate. This emphasis makes it clear that acquiring knowledge, equipment and technology abroad is no substitute for local efforts. Selection, purchases, copies, as well as the incorporation and use of these requires significant capacity-building ahead of time. Added to this is the fact that a crucial aspect of learning is related to the capacity to apply acquired knowledge and technology. Emphasis is, therefore, given to the relevance of policies that support national production development, because the capacity to generate and internalize new knowledge depends directly on its use.

Another essential aspect relates to the central role played by innovation in terms of dynamic and sustainable competitiveness and development. This contrasts with the usual priorities of the past, where traditional competitive advantages (related to low costs for labour, exploring natural resources with no reference to sustainability, and to the manipulation of interest and exchange rates represented the norm); termed spurious by Fajnzylber (1988).[12]

Similar are the advantages of designing and implementing policies that are appropriate for productive, innovative and territorial characteristics of the different production structures in the country. As previously indicated, extremely diversified dynamics can be found within the same sector. Besides capturing a mere part of innovation and production systems, the sectorial view ends up homogenizing the policy framework, as well as not keeping up with the constantly shifting frontiers within sectors. Both production and innovation are increasingly influenced by multidisciplinary and multi-sectorial knowledge. Knowledge concerning sectorial paths continues to be important, but should be contemplated from a perspective

[11] See Nelson (1993), e Mytelka (1993), Cassiolato et al. (2003), e Lastres et al. (2005).

[12] Also see Coutinho and Ferraz (1994).

of how companies are inserted within and maintain dialogue with production systems and the territories they belong to. This consideration is especially relevant for countries that are of continent size such as Brazil.

Defining national innovation systems also led researchers and policy makers to change the analytical and normative emphasis of their contributions. Fine-tuning individual and sectorial approaches makes them begin to incorporate the role and the dynamics of public and private organizations, the job market and capitals market, teaching and research organizations, government (as a whole instead of only the context of scientific and technological policy), as well as financing entities and other agents and elements that influence the acquisition, use and dissemination of innovation.

The systemic viewpoint began to penetrate the new analytical and policy benchmarks at the turn of the millennium. Studies and policy propositions have emphasized the importance of adopting such a stance, whilst stressing the need to acknowledge the specificities of each national innovations system, as well as the relevance of encouraging dialogue between agents. What stands apart the dual characteristics of the new generation of policies: innovation is now considered to represent the main component in development strategies—not only concerning science and technology or industrial policies—and policies addressing innovation are now understood as policies for innovation and production systems.

3.2 Lessons and Possibilities for Improving Innovation Policies in BNDES, Brazil and Throughout Latin America

At the beginning of the third millennium, the new policies for industrial and technological development face two major challenges: firstly, the reduced importance, across-the-board, of planning and policy support and, secondly, the expanding importance of financial capital in the world economy. The former markedly enabled and accelerated the latter. Recovering the capacity to plan and implement coordinated public and private development policies, within a long-term perspective, has proven fundamental. Similarly, there is a need to control and regulate the financing process, as well as to reshape innovation and production processes.

Advances in financial logic—preference for liquidity and a focus on short-term financial profitability—have significantly impacted the sphere of innovation and production, as well as the policies that mobilize it. One cannot ignore the fact that such an advance penalizes or even obstructs investments with high risk, costs and long-term maturity, such as those aimed at generating, assimilating and using knowledge. Without doubt, investments in STI, as well as in education and improving the capacity of human resources, all generate long-term results. Persistent macroeconomic restrictions continue challenging the possibility of implementing policy for STI. Exchange rate volatility and high interest rates both contribute to undermining investment in real and intellectual capital, in the long term.

As indicated, several authors, in keeping with the arguments developed by Furtado and Herrera, have shown how the macroeconomic conditions in less

developed countries do in fact represent important implicit policies and that certain malignant regimes contribute to eliminating a series of strategies as well as public and private development policies (Sagasti 1978; Katz 2000, 2005; Coutinho 2003; Erber 2004, 2008). Understanding and operating within these processes are fundamental. This must begin by overcoming apparent paradoxes, invariably identified in those analyses that miss the opportunity to capture the specificities of the different innovation and production systems, with their distinct ways of participating and articulating within the worldwide geopolitical context.

Demystifying the supposed neutral and universal nature of both the priorities for innovation and the policies for mobilizing them has definitely become the main challenge. Likewise, there is a need to align the national development model and project with public and private policies for industrial and STI development. Equally important is the challenge to implement these policies in scenarios where monitoring and assessing systems are strongly committed to:

- volume and speed of distribution
- performance indicators directed almost exclusively to assessing capacity for invention (R&D, patents and scientific publications).

As a result, priority is given to developing support, monitoring and assessment instruments that are coherent with the central goals of Brazilian policies. When policy targets are expanded, this creates an additional opportunity to include agents of varying sizes and the wide range of diversified production activities that exist throughout the five regions of the country in the support network.

Three major points summarize progress in terms of innovation knowledge with relevant policy implications. The first is recognition of the fundamental role played by innovation in aggregating value to goods and services and in fostering the systemic, dynamic and sustainable competitiveness of organizations, locations and countries. The second deals with acknowledging that the basis for the drive and competitiveness of organizations is not restricted to a singular organization or sector. Innovation depends on organizations, the interactions between them and also on other non-economic agents responsible for assimilating using and disseminating knowledge and capacity, inherent in different production systems, as well as the regions in which these organizations are situated. The third is that innovation and production activities differ in terms of time and space and present distinct policy requirements. The innovation and production capacity of a country or region—seen as a result of relations between economic, political and social agents—reflects local cultural and historical conditions. Different contexts, cognitive and regulatory systems as well as means of communicating and learning lead not only to different ways of generating, assimilating, using and accumulating knowledge, but also to specific policy requirements. This indicates the need to contextualize policy concepts and models.

The main lessons learned from past experience of innovation policy in Brazil indicate: (i) the need to overcome the mimetic and catch-up syndromes when using analytical and policy concepts and methodologies; (ii) the need for an awareness of the value of using concepts, indicators and models that encapsulate

political decisions; whilst ignoring the role of history and geography; dissociating social from economic development if they are capable of helping only a limited group of the most visible actors, activities and regions of the world; (iii) an understanding of how foreign experiences, concepts and models will broaden our knowledge without limiting our intelligence and that a significant part of the negative results of the policies implemented—creation of disparities, chasms and paradoxes—is related to de-contextualization.

Therefore, the main policy implications for understanding innovation as a contextualized, cumulative, non-linear and systemic process are significant and suggest an imperative need to design and implement adequate policies coordinated to local, regional and national development strategies; capable of stimulating cooperation and synergies aimed at expanding the use and dissemination of knowledge in production structures. Encouraging proposals and local processes, without suffocating them, must become a priority, whilst rejecting support models that are specific, but offer no commitment and that ignore local and national needs.

For obvious reasons, policies supporting innovation have tended to focus on production activities managed by leading business groups. However, these policies should still acknowledge the opportunities that might be encouraged when support is offered to activities contributing to social development. One that especially stands out is the importance of adopting a focus that does not restrict opportunities in terms of the policies implemented, particularly governmental policies. Example of this are essential public services, such as health care or education, which requires huge chains of suppliers and distributors of goods and services, innovation activities, which may involve both large corporations and significant numbers of legitimate and unregistered, micro and small enterprises.

As pointed out by Coutinho (2012), 'Taking on the challenge of eliminating hunger and extreme poverty and universalizing basic public services, such as education, health and sustainable urban spaces, reveals alternatives in innovation and industrial development, needed for the creation of a robust and long-lasting internal market. The main lessons learned from the crisis have shown that concerns previously understood as exclusively social, regional or environmental and for this reason not connected to the goals of economic growth—for example, distributing income and preserving water resources—are in fact at the core of public and private policy, aimed not only at increasing income, but also at broader, appropriate and sustainable development' (p. 13).

Hence, one aspect refers to the relevance of understanding the role of these basic services in improving the standards of living, and as a potential engine capable of mobilizing the entire production, innovation and consumption in local systems. Another aspect refers to the contribution these services make to efforts aimed at reducing regional inequalities, where implementation takes place in regions rarely covered by policy and that may also contribute to intensifying production activities, as well as generating jobs and income.

Authors such as Arocena and Sutz (2003, 2012) have emphatically called attention to the imperative need to contextualize STI policies in Southern countries, correlating them with the resources, capacity and specificities of these countries.

There has been a notable effort to generate solutions that will help resolve the serious problems associated with social inequality, characteristic of many less developed countries, instead of allowing these policies to contribute to reinforcing these problems. These authors also recall that since the beginning of the millennium, international agencies have recognized the need to explicitly incorporate social inclusion and development in worldwide agendas for STI. 'The first step is for countries to recognize that public health, food and nutrition, energy, communications and the environment are public policy issues that deserve serious attention through technology policy' (UNDP 2001: 114–115).

There is still a lack of studies assessing the potential of essential public services to employ, produce and innovate. The systemic magnitude of these services needs to be analysed in order to understand their innovative and economic importance, reinforcing the fact they should be incorporated in policy agendas. Analyses focusing on these services as avenues not only for social, but also for economic and regional development, have already addressed the matter of health care and education, expanding knowledge concerning possible ways to foster these systems and their respective local production arrangements.

In the case of health care, this analysis reveals a wide array of goods and services engaged by its system, encompassing the production and constant innovation of: equipments, materials, prostheses, implants, pharmaceuticals, phyto-therapeutics, IT services, laboratory examinations and tests, etc. Notably, on the one hand, there exists the power to leverage subordinate sub-systems. The hospital and laboratory network is an example with its significant demand for goods and services, where production has a high capacity for driving and generating employment possibly arising from a variety of sources, in keeping with the desirable effort to supply health services—especially with the actual and virtual access to these services. On the other hand, there is a high level and degree of complexity concerning the requirements associated with production and supply of diverse goods and services in the health system.

Similarly, the education system involves innumerous activities—transport, school meals, uniforms, furniture, materials, didactic information and communication systems and technologies—that may directly or indirectly offer a wide array of possibilities for employment, production and innovation. Similar to health, education is also an emblematic example of the need to operate systemically on national, macroregional and sub-regional scales.

Incorporating these guidelines will contribute to providing the tools and strength, as well as reinforcing the aim to reduce social and regional inequalities. A broader dialogue with the priority aims in Brazil's strategic development—such as 'Brazil with no Misery Plan' and the regional development policy, as well as the specific policies in areas such as health, education, housing and culture, etc.—may contribute to strengthening the innovation policy itself. It may also reveal important opportunities for generating, using and disseminating knowledge, whilst mobilizing and strengthening innovation and production arrangements spread across the entire country. The specific dynamics of the essential public services

segment allows and requires intense dissemination of successful innovations, in contrast to other cases where the competitive logic, private appropriation as well as protected and restricted use of innovation prevail.

The consequences of adopting policies that are capable of incorporating the wealth of knowledge accumulated in innovation—throughout the world and in Brazil, especially in the two last decades—are extensive and complex. Those that stand out include opportunities to implement contextualized and systemic policies that favour production and innovation capacity-building related to the main development goals of the country. In addition to the traditional focus on industrial development targets, there are the opportunities concerning the improvement of the supply of food, health, education, housing (with sanitation and access to water and electricity), culture and other essential public services. The result of advancing the agenda for local innovation and production would represent a significant expansion in the support of local systems and arrangements spread throughout Brazilian territory. This potential can be strengthened, if applied within an inclusive and sustainable vision of the future with the strategic aim of mobilizing and establishing knowledge intensive production structures.

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References

Arocena R, Sutz J (2003) Knowledge, Innovation and Learning: Systems and Policies in the North and South. In: Cassiolato J et al (eds) Systems of Innovation and Development. Edward Elgar, Cheltenham

Arocena R, Sutz J (2012) Research and Innovation Policies for Social Inclusion. In Lastres H et al (eds) A nova geração de políticas de desenvolvimento produtivo: sustentabilidade social e ambiental. Editora da CNI, Brasilia

Becker BA (2004) Amazônia e a política ambiental brasileira. GEOgraphia 6(11)

Cassiolato J, Lastres H (1999) Inovação, Globalização e as Novas Políticas de Desenvolvimento Industrial e Tecnológico. In Cassiolato J, Lastres H (eds) Globalização e inovação localizada: experiências de sistemas locais no Mercosul. MCT/IBICT, Brasilia

Cassiolato J, Lastres H (2009) Science, Technology and Innovation Policies in BRICS countries: an introduction. In Cassiolato J et al (eds) Development Altrnatives: Innovation Systems and Policies. Anthem Press, London

Cassiolato J et al (2003) Systems of innovation and development: evidence from Brazil. Edward Elgar, Cheltenham

Cassiolato J et al (2005) Innovation Systems and Development: what can we learn from the Latin American Experience? Paper presented at the III Globelics Conference in Pretoria

Cassiolato J et al (2008) Políticas estaduais e mobilização de atores políticos em arranjos produtivos e inovativos locais. In: Cassiolato J et al (eds) Arranjos produtivos locais: uma alternativa para o desenvolvimento. Experiências de políticas. E-Papers, Rio de Janeiro

Cassiolato J et al (2009) Technical change and structural inequalities: converging approaches about problems of underdevelopment. In: Drechsler W et al (eds) Techno-Economic Paradigms: Essays in Honour of Carlota Perez. Anthem Press, London

Economic Commission for Latin America and the Caribbean (2010) Time for equality: closing gaps, opening trails. ECLAC, Santiago de Chile

Chesnais F, Sauviat C (2003) The financing of innovation-related investment in the contemporary global finance-dominated accumulation regime. In: Cassiolato J et al (eds) Systems of innovation and development: evidence from Brazil. Edward Elgar, Cheltenham

Coutinho LG (2003) Macroeconomic regimes and business strategies: an alternative industrial policy for Brazil in the wake of the 21st century. In: Cassiolato J et al (eds) Systems of innovation and development: evidence from Brazil. Edward Elgar, Cheltenham

Coutinho LG (2008) Novas políticas para promoção de arranjos produtivos locais e a atuação do BNDES. In: Cassiolato J et al (eds) Arranjos Produtivos Locais: uma alternativa para o desenvolvimento. Experiências de políticas. E-Papers, Rio de Janeiro

Coutinho LG (2012) The new generation of sustainable development policies. In Lastres H et al (eds) A nova geração de políticas de desenvolvimento produtivo: sustentabilidade social e ambiental. Editora da CNI, Brasilia

Coutinho LH, Ferraz JC (1994) Estudo da Competitividade da Indústria Brasileira. Papirus, Sao Paulo

Couto MC et al (forthcoming) Innovation Systems and Inequality in the BRICS: an Introduction. In: Couto MC et al (eds) BRICS and Development Challenges: Inequality and National Innovation Systems. Routledge

Dosi G et al (eds) (1988) Technical change and economic theory. Pinter, London

Dutrenit G, Ramos C (2012) Towards building critical mass of science, technology and innovation: the Mexican experience in policy making. In Lastres H et al (eds) A nova geração de políticas de desenvolvimento produtivo: sustentabilidade social e ambiental. Editora da CNI, Brasilia

Erber F (2004) Innovation and the development convention in Brazil. Revista Brasileira de Inovação 3(1)

Erber F (2008) Eficiência coletiva em arranjos produtivos locais industriais: comentando o conceito. Nova Economia 18(1)

Fajnzylber F (1988) Competitividad internacional: evolución y lecciones. ECLAC Review 36

Freeman C (1982) Technological infrastructure and international competitiveness. OECD ad hoc group on science, technology and competitiveness. OECD, Paris

Freeman C (1987) Technology policy and economic performance. Lessons from Japan. Pinter, London

Freeman C (1999) Innovation systems: city-state, national, continental and subnational. In: Cassiolato J, Lastres H (eds) Globalização e inovação localizada: experiências de sistemas locais no Mercosul. MCT/IBICT, Brasilia

Freeman C (2003) A hard landing for the 'New Economy'? Information technology and the United States national system of innovation. In: Cassiolato J et al (eds) Systems of innovation and development. Edward Elgar, Cheltenham

Furtado C (1961) Desenvolvimento e Subdesenvolvimento. Fondo de Cultura, Rio de Janeiro

Furtado C (1998) Capitalismo global. Paz e Terra, Sao Paulo

Garcez C et al (2010) Análise de políticas para arranjos produtivos locais no Brasil: uma introdução. In: Apolinário VE, Da Silva ML (eds) Análise de Políticas para Arranjos Produtivos Locais em Estados do Nordeste e Amazônia Legal. Editora da UFRN, Natal

Guimaraes V et al (2006) Convergências e complementaridades da corrente neo-schumpeteriana com o prensamento estruturalista de Celso Furtado. In: Saboia J, Cardim F (eds) Celso Furtado e o século XXI. Manole, Rio de Janeiro

Herrera A (1971) Los Determinantes Sociales de la Política Científica en América Latina. In: Sábado J (ed) El pensamiento Latinoamericano en ciencia-tecnología-desarrollo-dependencia. Paidós, Buenos Aires

Jewkes J et al (1958) The Sources of Invention. Macmillan, London
Johnson B, Lundvall B-A. Promoting innovation systems as a response to the globalising learning economy. In: Cassiolato J et al (eds) Systems of innovation and development. Edward Elgar, Cheltenham
Kaplan E et al (2011) Os grandes projetos federais e o desenvolvimento do Nordeste: uma introdução. In: Apolinário V, Da Silva ML (eds) Impactos dos Grandes Projetos Federais sobre os Estados do Nordeste. Editora da UFRN, Natal
Katz J (2000) Globalización, Reformas Estructurales y Sistemas Innovativos. Serie Desarrollo Productivo 75, ECLAC
Katz J (2005) O novo modelo econômico latino-americano: aspectos de eficiência e equidade que colocam em questão a sua sustentabilidade. In Lastres H et al (eds) Conhecimento, Sistemas de Inovação e Desenvolvimento. Editora UFRJ/Contrapronto, Rio de Janeiro
Katz J (2008) Una nueva visita a la teoría del desarrollo económico. ECLAC
Lastres H, Cassiolato J (2005) Innovation Systems and Local Productive Arrangements: new strategies to promote the generation, acquisition and diffusion of knowledge. Innovation: Management, Policy and Practice 7:172–187
Lastres H, Cassiolato J (2011) Inovação, arranjos produtivos e sistemas de inovação. In: Amaral Filho J, Carrillo J (eds) Trajetórias de Desenvolvimento Local e Regional. E-Papers, Rio de Janeiro
Lastres H, Ferraz J (1999) Economia da informação, do conhecimento e do aprendizado. In: Lastres H, Albagli S (eds) Informação e globalização na Era do Conhecimento. Campus, Rio de Janeiro
Lastres H et al (2005) Sistemas de inovação e desenvolvimento: mitos e realidades da economia do conhocimento. In Lastres H et al (eds) Conhecimento, Sistemas de Inovação e Desenvolvimento. Editora UFRJ/Contrapronto, Rio de Janeiro
Lastres H et al (2010) O apoio ao desenvolvimento regional e aos arranjos produtivos locais. In: Alem AC et al (eds) O BNDES em um Brasil em transição. BNDES, Rio de Janeiro
Lastres H et al (2012) A nova geração de políticas de desenvolvimento produtivo: sustentabilidade social e ambiental. Editora da CNI, Brasilia
Lundvall B-A (1985) Product innovation and user-producer interaction. Aalborg University Press, Aalborg
Mowery D, Rosenberg N (1979) The Influence of Market Demand upon Innovation: a critical review of some recent empirical studies. Res Policy 8
Mytelka LK (1993) A role for innovation networking in the other two thirds. Futures 25
Nelson R (1993) National Innovation Systems. A Comparative Analysis. Oxford University Press, Oxford
Perez C (2010) Technological dynamism and social inclusion in Latin America: a resource-based production development strategy. ECLAC Review 100
Perroux F (1999) L'Economie du XX Siècle. Presses Universitaires de France, Paris
Polanyi M (1966) The tacit dimension. Routledge & Kegan, London
Saboia J, Carvalho FJC (eds) (2007) Celso Furtado e o Século XXI. Manole, Rio de Janeiro
Sagasti F (1978) Science and Technology for Development: Main Comparative Report of the Science and Technology Policy Instruments. STPI, IDRC, Ottawa
Santos M (2001) Por uma outra globalização: do pensamento único à consciência universal. Record, Rio de Janeiro
Scerri M, Lastres H (eds) (2013) The State and the National System of Innovation: A comparative analysis of the BRICS economies. Routledge, New Delhi
Schumpeter JA (1939) Business cycles: a theoretical, historical and statistical analysis for the capitalist process. McGraw-Hill, New York
Schumpeter JA (1942) Capitalism, socialism and democracy. Harper, New York
Tavares MC, Fiori JL (eds) Poder e dinheiro: uma economia política para a globalização. Editoria Vozes, Rio de Janeiro
UNDP (2001) Human Development Report: Making New Technologies Work for Human Development. UNDP, New York

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Inclusive Innovation Against All Odds: The Case of Peru

Juana R. Kuramoto

Abstract Policy design and implementation can be influenced by the diffusion of ideas. That was the case of science and technology policy during the 60s and 70s. International organisations helped in this diffusion, but developing countries were not ready to make such policy reforms. As a result, policies were poorly implemented and were difficult to coordinate with other policies even when the latter were national objectives. That was the case regarding science and technology and social inclusion policies in Peru. However, the priority of reducing poverty has indirectly contributed more to technology transfer than the actual science and technology policy. The strategy of strengthening production chains to connect poor producers to dynamic markets and the focus on demand proved to be very effective. Science and technology policy requires an adequate institutional setting that eases coordination among the different actors involved and provides resources and capacities to attend the demands of society.

1 Introduction

One of the most remarkable features of the Peruvian economy during the last decade was its sustained growth. During the period 2000–2010, GDP increased almost threefold from US$53,337 million to US$153,919, which meant a two-fold increase in the GDP per capita from US$2,054 to US$5,224. The paradox is that productivity growth did not grow at the same pace, although there is a

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growing trend of productivity increase. During the period 1996–2005, total factor productivity (TFP) grew 0.7 %, while TFP growth was 1.5 % between 2006 and 2010 and it reached 2.2 % in 2010 (The Conference Board 2013). Some economists argued that Peruvian growth has been guided mainly by the increase of factors (Castillo et al. 2008). During the same period, poverty figures diminished from 54.7 % in 2001 to 31.3 % in 2010. Although growth has definitely contributed to this reduction, many forget that social public expenditure increased 50 % (CEPAL 2012).

Peru, like many other countries, has a complex set of policies that most of the time are designed and implemented independently from each other. Thus, in some cases, the policy scenario may overlap and may even set contradicting incentives.

During the last two decades, there has been a public discourse in Peru declaring that science, technology and innovation (STI) policies should be a corner stone for economic growth and social development. However, the design and implementation of such policies have been limited. Peru has one of the lowest figures for research and development in the region (0.12 % of GDP in Peru compared to 0.75 % of GDP for Latin American countries). It also has no more than 10 policy instruments in STI, whereas Mexico has more than 70.

These contradictions between the major policy declarations and results sometimes are the consequence of the international diffusion of policy ideas that push countries to make reforms they may not be ready to implement. The latter does not mean that countries must be isolated from the advances in the design of new policies. It rather stresses that policy reforms are usually rushed in and implemented without setting the basic conditions for their sustainable functioning, such as adequate funding or human resources with the adequate technical skills.

This chapter claims that was the case for the STI policy implemented in Peru. Nobody can deny its importance as a support of an overall economic and social development strategy, especially after the evidence provided by the experience of different generations of catching-up countries. However, the implementation of that policy requires an adequate organisational design of the basic institutions that will implement a clear division of labour among them, coordination mechanisms and sufficient funding among others. And most importantly, it requires political commitment to convert it in one of the central policy nodes that guide the actions of government. It is only in this way that the STI policy can be articulated with other important policies such as social inclusion.

The next section presents the concept of diffusion of policy ideas and the role of international organisations as agents of this diffusion. It will also describe the role that United Nations Educational, Scientific and Cultural Organization (UNESCO) played in the implementation of science bureaucracies around the world as well as a brief presentation of the adoption of the innovation system conceptual framework in developing countries. Section 3 presents the specific problems faced by Peru in the adoption of STI policies and how it resulted in an institutional system with problems of governance that has a limited performance. Section 4 will show the disconnection of STI policy with a social inclusion one. Even when the National Plan for Science, Technology and Innovation states

that this policy will be at the service of human development, with the exception of technology transfer programmes, there are no other policy instruments aimed specifically to achieve this goal. Section 5 presents some social inclusion projects aimed at eradicating poverty that have contributed massively to transfer technology and strengthened production chains that linked small rural producers with dynamic domestic and international markets. Finally, Sect. 6 presents the conclusions of this chapter.

2 External Influence in the Adoption of Science, Technology and Innovation Ideas

There is a growing body of literature on the diffusion of policy areas and instruments. Weyland (2005) analysed the diffusion of policy reforms in Latin America (i.e. pension system reform) and found that these follow a pattern that could be described as an S-shaped pattern, similar to those patterns found in the epidemic model of technological diffusion. Once a policy reform is implemented, it may attract the attention of neighbouring countries that will usually make a rapid assessment of the reform. Successful reforms in the first-mover countries will ease the implementation in the imitating countries. A few countries will follow at the beginning, and as the diffusion gains momentum, some others will join at an increasing speed.

Weyland (2005) also found that countries adopt reforms without changing much of the original design. He suggested that government officials that are responsible for the implementation of such reforms presented bounded rationality. In addition, international organisations may play an active role in promoting such reforms. Thus, via technical assistance, they will influence government officials in policy adoption. On their side, government officials may want to gain international legitimacy by importing advanced innovations and may demonstrate the country's modernity and its compliance with new international norms.

Weyland (2009) alerted that institutional models and blueprints that do not emerge from actor preferences but are transferred to a different setting often fail to command firm, reliable compliance and do not operate well. The main risk is that some of the transferred models may lack the prerequisite conditions to operate effectively; thus, informal mechanisms are put in place to make it work, but eventually domestic actors return to old behaviours that may undermine the proposed reform.

2.1 Science Bureaucracies

In the specific field of science policy, Finnemore (1993) analysed the role of the UNESCO in the setting up of science policy bureaucracies. The author argued that the adoption of this state reform may have responded to demand stimulus in

developed countries but that was not necessarily the case in developing countries. UNESCO supplied the organisational innovation to these countries' governments to fulfil the new international norm of state's responsibility for science.

In fact, the experience of developed countries may have responded to a demand-driven explanation. The increase in scientific activity in these countries pushed for a change in state's science policy organisations to direct and control this activity, as well as to establish a means for providing state aid and coordination (Finnemore 1993). Indicators such as percentage of GDP spent in research and development (R&D) activities, proportion of scientists and engineers in the population, GDP per capita and percentage of GNP spent on defence justified the thesis of a demand-pull for such bureaucracies in developed countries during the 1950s and 1960s.

However, during the same period, "a large number of small, poor, technologically unsophisticated, and militarily unthreatened countries created these bureaucracies" (Finnemore 1993, p. 573). For example, Guatemala created in 1966 its Consejo Nacional de Investigaciones Científicas y Técnicas with UNESCO's help. By that time, Guatemala reported only 14 scientists employed in R&D jobs, spent 0.01 % of GDP on research, had a GDP per capita of $806 and spent only 1.07 % of GNP on defence.

For developing countries, a supply push explanation is more plausible. Evidence showed that by the late 1950s, UNESCO began actively to assist countries in setting up science policy organisations. It also developed a mission statement to support that role: "the Science Policy Programme of UNESCO is formulated on the basis on the principle that the planning of science policy is indispensable" (Finnemore 1993, p. 583). The outcome is that around 70 % of the member states created science policy organisations in the period 1955–1975. The percentage rose to 84 % in the period 1976–1980 (Finnemore 1993).

2.2 Innovation Systems Conceptual Framework

The innovation systems notion was born as a conceptual framework that helped understand the different ways in which technological change is experienced in different countries and how it contributes to economic growth. In fact, Freeman (1987) deployed the innovation systems framework to explain the economic success of Japan, and in a later paper, he made a comparative analysis between South East Asian and Latin American innovation systems (Freeman 1995).

The framework became so popular during the 1990s that it evolved from a descriptive concept to a normative one. The stylised facts of successful innovation systems soon became policy recommendations for developing countries. Arocena and Sutz (2005) stated that the vision of developing countries with regards to innovation systems would be centred in four aspects: (a) for developed countries, it is an ex-post concept, borne on the basis of empirical findings; while for developing countries, it is an ex-ante concept; (b) it carries a normative weight; (c) it has a relational focus;

(d) it is a political subject that helps describe the power struggles within the process of innovation; and (e) it describes situations in which conflict is present (page 9).

Just like in the case of science bureaucracies, the innovation systems framework began to guide the STI policy of developing countries, although its adoption presented some problems. Intarakumnerd et al. (2001) identified some stylised facts in developing countries, such as the disarticulation and lack of interaction among the different components of the innovation system, the limited technological capabilities of firms, the lack of coherence among innovation policies and the rest of sectoral policies, among others. Authors such as Cooper (1999) and Gu (1999) stated that these systems are not static, on the contrary, these are constantly co-evolving with the productive structures, institutions and the level of development of countries. Thus, there cannot be a unique innovation systems model, and it must respond to the specific characteristics that prevail in the countries where it is implemented.

Arocena and Sutz (2002) recommended a strategy for building innovation systems in developing countries that begins with a diagnostic of the learning processes that takes place in them. The authors stressed the importance of the interactions among actors and/or the absence of such interactions. The strategy should be based on concrete policies that take in account the interests, needs and possibilities of the different actors potentially involved in innovation processes. It also needs to be based on a "bottom-up" perspective rather than on pursuing optimal situations that may be impossible to attain given the capabilities of actors and the incentives that govern the actual systems.

The diffusion of the innovation systems was first promoted by the academia and, later, by international organisations that converted it in a policy tool. After Freeman (1987), many other economists used the same approach to explain the scientific and technological efforts invested by different countries and the economic results they experienced. Universities such as the University of Sussex in the United Kingdom, the University of Maastricht in the Netherlands and the University of Aalborg in Denmark, among others, have produced several doctoral theses using the innovation systems framework. In addition, research networks, periodic conferences and specialised journals have also served as diffusion mechanisms of this conceptual framework.

Many of the professionals that were trained in the universities mentioned above became officers of different development agencies that develop policy tools that were transferred to help countries organise and manage the STI organisations in different countries. These development agencies soon developed different policy products such as STI scorecards, innovation surveys, designs for technology and innovation funds, among others that were diffused in the member countries they work with.

The OECD and the European Community have been very active in promoting programmes, projects and policy instruments based on the innovation systems framework in European countries.

In the specific case of Latin America, the Inter-American Development Bank (IADB) is one of the most active development agencies for diffusing STI concepts. Since 1961, the IDB had the objective of promoting progress in science and technology in Latin America via its lending and technical

assistance for research and postgraduate studies at universities. During all these years, the IDB has expanded the number of policy instruments that it offers to its member countries. They include the following: technology development funds; funds for financing research and S&T services through competitions; human resource training; infrastructure strengthening; technology diffusion; information and popularisation; and study and coordination of national innovation systems' policies (Mayorga 1997).

The IDB identified innovation systems as an interface where science, technology and economic development overlap. It also found that the lack of internalisation of technological change in Latin American economies was the consequence of the weaknesses of their innovation systems. Therefore, the core of an effective strategy should be the strengthening of systemic capabilities and helping countries to coordinate public policy and create incentives for system-wide collaboration among NIS stakeholders (Mayorga 1997).

The IDB loan operations have become complex because they try to integrate different policy instruments. For example, Colombia has just presented a loan proposal of US$25 million to strengthen the national science, technology and innovation system. The specific objective is to help strengthen the National Science, Technology and Innovation System (SNCTI, the acronym in Spanish) by strengthening Colciencias, enhancing and coordinating innovative capacities in specific economic sectors, and increasing private investment in innovation.

Just as UNESCO had an active role in promoting the creation of a scientific bureaucracy during the late 1950s and 1980s, the IDB, via the STI country loans, is promoting a series of policy instruments to strengthen the innovation systems in the member countries.

3 External Science, Technology and Innovation Ideas and the Problem of Institutional Governance

Peru, like many other countries in the Latin American region, received external assistance to implement a scientific and technological bureaucracy. Technical assistance to design and implement an institutional framework for science and technology dates back to 1966. Peruvian scientists participated in a series of workshops with the US National Academy of Sciences (US-NAS) to stress the importance of science and technology in economic development. This participation evolved into a technical assistance to improve scientific and technological research and education in Peru. The focus of this technical assistance was the creation of a National Research Council. A commission of Peruvian scientists and representatives of the US-NAS had an interview with the Peruvian President, Fernando Belaúnde, but he showed no interest in the proposal (Brown and Tellez 1973).

Peruvian scientists continued with their collaboration with the US-NAS. It seems that UNESCO also provided some technical assistance to the Peruvian government, and two organisational models were evaluated. The outcome of the collaboration

with US-NAS was reflected in an organisational model to coordinate and organise the scientific research performed in Peru. The model included 3 functional levels. The first level was responsible for the planning and funding of scientific research. It would be constituted by the Consejo Nacional de Investigación, which would design the science and technology policy and would also secure adequate funding. The second level would be in charge of the inter-scientific coordination. It would be composed by different scientific organisations aiming at contributing to knowledge advancement and to foster cooperation to provide solutions to societal problems. The third level would be focused on research execution. It would be formed by various scientific institutions, universities and laboratories (National Academy of Sciences 1967).

In 1968, under a military government, the Consejo Nacional de Investigación was created. However, the Consejo never had a funding mechanism to secure its research activities; instead, a series of sectoral research institutions were created. Their funding was secured via the retention of a percentage of firms' gross profits. However, investment in R&D remained very low with regard to international standards. In 1970, the investment in R&D was only 0.13 % of the GNP, in 1975, it reached 0.36 %, and in 1981, it fell to 0.28 %.

As opposed to the 3-level organisational framework, a centralised framework was put in place, with the Consejo as a mega institution that would design, fund, implement and coordinate policy. Firms had little space within this framework and, therefore, it lacked mechanisms to channel the science and technology demand of the private sector. With the exception of the ITINTEC, the Institute of Industrial and Technological Research and Technical Standards, which funded technological research based on firms' proposals, the rest of the public research institutions had agendas dominated by the supply side.

During the next decades, the organisational design remained the same. However, the economic crisis during the 1980s reduced drastically the government funding for S&T activities. The National Council for Research became the National Council for Science, Technology and Innovation (CONCYTEC), but remained underfunded and lost the little political clout it may have had at one point.

It was only in the late 1990s, that some attention was given again to science and technology issues. In this decade, the new concepts that were promoted internationally were the knowledge society and innovation systems. Although these terms were soon adopted in Peru, the organisational structure of the whole STI system remained the same and with little funding. According to RICYT,[1] in 1997, Peru invested in R&D only 0.08 % of GDP while the average investment in the Latin American and the Caribbean countries was 0.71 %.

The first organisational changes were made in 2004, when the National Law for STI was enacted (Law No. 28303). Although the law declared that "the development, promotion, consolidation, transfer and diffusion of Science, Technology and Technological Innovation are a public need and of national interest, as fundamental factors for productivity and national development" (article 2, Law No. 28303), funding remained below 0.15 % of GDP.

[1] RICYT is the Latin American Network for Indicators on Science and Technology.

This law also introduced the concept of National System of Science, Technology and Technological Innovation that resembled that of the innovation system; however, the CONCYTEC maintained its primacy as a coordinating, promoting, funding and articulating institution. Although, the law also created the National Fund for Scientific and Technological Research and Technological Innovation (FONDECYT), it was administratively subsumed in CONCYTEC. The rest of the institutions that execute S&T activities were supposed to coordinate with CONCYTEC, but the fact was that the latter had no effective mechanisms to perform any of the tasks that were commanded by law.

The Peruvian innovation system had all the components that function in developed countries, but they were extremely weak and underfunded. In addition, policy design was very simplistic; it usually resulted in a wish list of knowledge areas that should be developed, but no operational plans were developed or any budget was assigned to implement S&T activities. As a result, the Peruvian innovation system failed to perform almost all of the functions it was expected to accomplish.[2]

A recent review on Peru's science and technology policies performed by OECD (2011) mentioned that the inability to address the main weaknesses of the innovation system are a confusion between policy design and programme funding and management which can create conflict of interest regarding the use of resources; the excessive broad missions of funds and institutions which cover the whole range of the S&T policy areas; and institutional rigidities and legalistic culture that hinder the development or the effectiveness of new policy instruments within the existing institutional architecture (page 17).

In general, the weakness of the components of the innovation system and its lack of articulation affect the overall governance. In addition, the lack of financing increases fragmentation of programmes that lack critical mass and have no meaningful effect and fail to generate synergies.

OECD's recommendations to improve governance offered three design options: the creation of a new Ministry of STI; a decentralised government agency as the executive arm of a high-level government body with inter-ministerial coordination responsibilities for policy design and implementation; and an inter-ministerial body in charge of defining strategic policy orientation and budgetary appropriations with a series of implementation offices.

OECD recommended the third option because it would attend the necessity of creating a policy decision body at the highest level of government that would be able to set the agenda for S&T. A division of labour would be established between CONCYTEC and the Ministry of Economics and Finance and the Ministry of Production. The former would be in charge of funding scientific research and technological development through institutional and competitive funding, human resource development and the assessment of public research institutes. The latter

[2] According to Hekkert et al. (2007) there are seven functions that innovation systems should perform: (1) knowledge development and diffusion; (2) influence on the direction of search; (3) entrepreneurial experimentation; (4) market formation; (5) legitimation; (6) resource mobilization; and (7) development of positive externalities.

ministries would be in charge of funding innovation funds for the private sector and technology diffusion and transfer. This option would better fit the current institutional setting while eliminating the duplication of functions.

UNCTAD (2011) also assessed the Peruvian innovation system arriving to similar conclusions. The UNCTAD proposal also recommended a decentralised option that secured division of functions. On the one hand, the creation of a National Council of Innovation that would be directly linked to the Presidency of the Ministries Council and would be responsible for the definition of the strategic policy guidelines in STI. On the other hand, the creation of a Peruvian Agency of Innovation that would be responsible for the funding and execution of STI programmes.

In any case, both recommended options separate clearly the priority setting and policy design functions from the execution of STI activities, as well as try to avoid duplication of mandates and secure enough funding.

4 Social Inclusion Within Science and Technology Policy

4.1 STI Policies Disconnected From Tangible Social Objectives

The National Plan for Science, Technology and Innovation for Competitiveness and Human Development (PNCTI) was formulated in 2005. It was the first time that a STI plan would explicitly state that science and technology would be at the service of human development. The plan made a lot of emphasis on its demand approach, which was much in line with the innovation systems approach adopted by the Peruvian government.

The PNCTI was also very influenced by the establishment of the United Nations Millennium Project in 2002, which aimed at developing a concrete action plan to reverse poverty, hunger and disease in the world.[3] Just like the

[3] A Commission led by Jeffrey Sachs defined eight Millennium Goals: (a) eradicate extreme hunger and poverty; (b) achieve universal primary education; (c) promote gender equality and empower women; (d) reduce child mortality; (e) improve maternal health; (f) combat HIV/AIDS, malaria and other diseases; (g) ensure environmental sustainability; and (h) develop a global partnership for development. The Commission was formed by 10 task forces that analyzed specific issues related to the main goal of reducing poverty, hunger and disease. One of these reports, *Innovation: Applying Knowledge in Development*, highlighted the significant role that science, technology, and innovation can play in implementing the Millennium Goals. The basic assumption that guided this report was that most of the goals cannot be achieved without a framework of action that places STI at the center of the development process. The STI report recommended approaches for effectively applying STI to achieving the goals that included: the use of generic technologies that may have broad applications or impacts in the economy; the improvement of infrastructure as a foundation for technology; the improvement of higher education, especially in science and engineering; the improvement of the policy environment; and the focus on areas of underfunded research for development (UN Millennium Project 2005).

earlier adoption of scientific bureaucracies and the concept of innovation systems, the PNCTI embraced the goal of contributing to human well-being. However, a closer look at the plan shows there is a clear disconnection between this goal and the strategies and priorities set. For example, the global objective of the plan is "to secure the articulation among the actors of the National System of STI, focusing their efforts to attend the technology demands in strategic areas with the aim of increasing value added and competitiveness, improving the quality of life of people and contributing to responsible environmental management" (CONCYTEC 2005).

However, none of the eight long-term goals of the plan are related to any indicator of human development; on the contrary, all of them are referred to STI indicators. In the same fashion, from the four strategic objectives, the second one vaguely refers to steering scientific and technological research to solve problems and attend the demands of the strategic areas defined by the plan. However, none of its strategies explicitly refer to the solution or demands posed in order to achieve human or social development.

Another major long-term policy tool is the Bicentenary Plan that presents the development goals for the year 2021, a milestone that reminds us of the 200th anniversary of the Declaration of the Independence from Spain. The Bicentenary Plan defined six strategic lines that included the following: (a) fundamental rights and dignity of people; (b) opportunities and access to services; (c) state and governability; (d) economy, competitiveness and employment; (e) regional development and infrastructure; and (f) natural resources and environment (CEPLAN 2011). Objectives, guidelines, priorities, goals, actions and strategic programmes were defined for each strategic line. No STI goals or actions were defined to address the objectives in the first and the second strategic lines, which were related to the issues of poverty and human development. In the same way, the objectives, priorities and actions related to the strategic line of Economy, competitiveness and employment, where S&T issues were subsumed had no relation whatsoever to poverty or human development.

These two examples showed the disconnection between STI policies and those related to poverty alleviation and human development. The major statements were formulated, but there were no concrete actions to pursue them.

4.2 Technology Transfer and Extension Services as Social Inclusion Instruments

In the specific area of technology transfer, that is usually meant to diffuse technology for the benefit of small producers, some major changes occurred only in the late 1990s. This section will present two policy instruments implemented in the beginning of the 2000s that had a major impact: the Innovation and Competitiveness Programme for Peruvian Agriculture, INCAGRO and the network of Technological Innovation Centers (CITEs).

4.2.1 INCAGRO

After facing the same financial constraints suffered by other STI agencies, the agricultural extension services also entered in crisis. Ortiz (2006, cited by Preissing 2012) stated that Peru's extension agricultural services became financially unsustainable owing to government financial limitations, privatisation trends and the inhibiting presence of the Shining Path guerrilla group. In addition, the system was considered too centralised and too supply-driven. This extension system was not suitable any more with the increasing modernisation that this sector was experiencing;[4] counter-season crops mainly linked to the export markets changed the focus of agriculture extension instruments towards a decentralised, demand-oriented, co-founded and out-sourced model (Rosebloom et al. 2006).

In addition, as it will be described in the next section, different poverty reduction programmes began to promote production/value chains that had a strong component of technology transfer and technical assistance. Most of these programmes proved to be quite effective in modernising the technological transfer model and to generate a market for technical assistance services.

Within this context, in 1999, the Peruvian government signed a letter of intent with the World Bank to promote agricultural innovation through the Bank's Adaptable Loan Programme. The resulting Innovation and Competitiveness Programme for Peruvian Agriculture, INCAGRO project, had as its main objective to establish a national agricultural science and technology system that would be modern, decentralised, demand-driven and led by the private sector. INCAGRO had three components. First, the Agricultural Technology Fund financed agricultural extension for projects developed by farmer organisations. Farmers contracted extension providers to complete a specified number of activities and were required to make a financial contribution in cash, plus any in-kind contributions. Second, the Strategic Services Development Fund used competitive matching grants to promote basic and applied strategic research. It focused on genetic resources, biotechnologies, plant and animal protection, natural resource management, post-harvest technologies and conservation agriculture. Third, a monitoring and evaluation component that would help assess the projects funded by INCAGRO (Preissing 2012).

In general, INCAGRO was successful. The final evaluation of the project[5] indicated that in its two phases,[6] INCAGRO founded 487 projects and benefited

[4] Eguren (2006) stated that the economic reforms in the 1990s paved the way to the development of a modern agriculture geared towards external markets. He specially mentioned that the elimination of restrictions in land markets and corporate investments were crucial to the expansion of a modern agro-exporting sector in the Coast.

[5] INCAGRO's final evaluation was performed using a decomposition method instead of a typical quasi experimental method. Salles-Filho et al. (2010) stated that this methodology was more suitable for a technology program which comprised different types of innovation. The decomposition method comprised two main elements: decomposition of the formal and informal goals of the program obtained from documents and interviews), and dialogue with the participants through structured panels.

[6] A third phase of INCAGRO was planned but the project was aborted in 2010.

directly 72,762 producers and indirectly around 580,000. The INCAGRO budget destined around S/. 110 million (approximately US$39 million) and was able to leverage S/. 49.4 million (US$17.5 million) via strategic alliances' contributions, and it generated as well more than S/. 220 million (US$78 million).[7] Table 1 reports some selected technological results from the producers' perspective, although the evaluation covered different actors' perspective such as directives of producers' associations, providers of extension services, clients of extension services and researchers.

The information reported stated that the STI behaviour of producers has changed towards an important adoption rate of new knowledge, technologies (59 %) and practices (81 %). It also indicated that there was an increase in the willingness to pay for these services (59 %). In terms of competitiveness, the data showed that there was a positive effect in the introduction of new land for new productive uses (50 %), as well as that the volume of production was doubled.

With regards to social sustainability, the evaluation report found an important increase in hired and familiar employment (rate of 181 % increase); however, female employment increase was more modest (17 %). Environmental sustainability indicators showed an important reduction in chemicals (68 %) and an important adoption rate of soil preservation techniques (74 %). Other environmental practices had more modest adoption rates (25 % increase in biodiversity preservation practices and 23 % increase in ecosystem recovery practices in degraded areas).

Finally, there was an increase in the supply of technological and innovation services (30 %) and a perception that these services have improved (99 % believe that the quality of technological and innovation services has increased 26 % in the last years).

INCAGRO was the first STI instrument that was evaluated in Peru. Its results helped to convince various stakeholders, especially the Ministry of Economics and Finance, that innovation programmes could be useful to improve competitiveness and the well-being of people. It also showed that these programmes could be profitable, as the income generated by the project doubled its executed budget (S/. 220 million against S/. 110 million).

Despite these positive results, another evaluation component was related to the institutional strengthening of the agricultural innovation system. A World Bank report found this component unsatisfactory after the first phase of the project was completed. The report stated that this component, on the one hand, was intended to build capacity in selected programmes of strategic significance in the national technology system; however, the weakness and relative isolation of most of the institutions working in the area hindered this objective. On the other hand, another priority was the strengthening of the National Institute for Agricultural Research (INIA). A series of studies to support INIA's strategic planning were conducted, but there was a lack of political commitment on the part of the government, and the studies were shelved (The World Bank 2005).

[7] The 2010 average exchange rate was S/. 2.826 per US$1.

Table 1 Some INCAGRO results from the producers' perspective

Area of impact	From the producers' perspective
Scientific and technological development and generation of innovations	• 59 % of producers adopted technological innovations • 81 % acquired new production practices
Propensity to innovate	• 59 % increase in the propensity to acquire new technologies and knowledge • 77 % report an increase in 51 % in the willingness to pay for knowledge and activities that promote innovation
Competitiveness	• 50 % is the reported influence of INCAGRO to introduce new land for productive activities or for substitution activities • 100 % is the average impact of the programme to the increase in production
Social sustainability	• 57 % considered that the hiring of workers has increased • Employment, hired and familiar, has increased almost 180 % • 77 % report changes in association and cooperation conditions among producers • 17 % increase in female employment
Environmental sustainability	• 68 % reduced the use of chemicals • 74 % adopted soil preservation practices • Increase of 25 % of biodiversity preservation practices • Increase of 23 % of ecosystem recovery practices in degraded areas
Market of services	• Increase of 30 % in the supply of technological and innovation services • 99 % believe that the quality of technological and innovation services has increased 26 % in the last years

Source Partial data found in Dias et al. (2010)

The lack of consensus over the agricultural innovation system design led in 2010 to the cancellation of the INCAGRO project, even when it was planned to initiate a third phase with a budget of US$140 million. The new INIA, changed to National Institute for Agriculture Innovation, included in its mandate the funding of extension services and absorbed INCAGRO. However, the World Bank considered that the conditions offered by INIA to continue with INCAGRO did not guaranty an effective functioning, and both the loan and project were cancelled (Agencia Agraria de Noticias 2011).

The cancellation of the INCAGRO project is another piece of evidence of the overall incoherence of the STI policy in Peru and its lack of governance. From a management perspective, a well-managed project was transferred to a weak institution with no capabilities to run it. From a policy perspective, an instrument that proved to effectively fund extension agricultural services was cancelled and, after 2 years, was not replaced with an alternative instrument. Thus, leaving unattended a growing demand for extension services and curtailing the possibilities of social inclusion via STI policy.

4.2.2 CITEs

The network of Technological Innovation Centers (CITEs) is a policy instrument designed by the Ministry of Production to enhance firms' innovation capabilities and foster their productivity and competitiveness. Three CITEs were created between 1998 and 2000, as a result of an agreement signed by the former Ministry of Industry, Tourism and International Trade, the Export Promotion Office and the Government of Spain. CITE-ccal was aimed at the technological upgrading of the Peruvian leather and footwear fabrication. CITEvid is a specialised institution in viticulture sponsoring aimed at improving the quality, productivity, information and innovation of the different links in the pisco and wine-making chain, as well as support the domestic and international promotion of pisco. CITEmadera was aimed at improving innovation and quality in the wood and furniture industry.

After 2000, 14 new CITEs were created by private organisations, although at present only 10 private CITEs work. These provide technological services to firms in different production chains.[8] Services include the following: technical assistance; assays, tests, certifications and conformity to technical standards; pilot plants demonstration; diffusion of technical information; studies and analyses of world trends in relevant production chains; training services, elaboration of market studies, among others.

After 13 years of operation, the CITEs programme filled a void in the Peruvian industrial policy. It is the only policy instrument that provides technical assistance and other technological services to industrial firms, although some of the CITEs target agricultural firms but usually as actors that belong to a production chain that delivers a processed product.

However, the CITEs programme has a lot of limitations according to a recent evaluation study. First, Sierra (2012) suggested the programme suffers from the lack of an adequate framework of a technological diffusion policy that may complement the provision of technological services with measures aimed at increasing the demand of firms. Second, limited public funding was a major constraint for this programme. Public CITEs received some operational budget from the government, but it did not allow for growth or the upgrading and the expansion of the services offered, whereas private CITEs do not receive any public funding and that seriously limited their technological infrastructure and the services they offer. Third, as a consequence, the market they attended is very limited compared to the universe of industrial firms. At present, there are 13 CITEs operating all over Peru, while the number of firms is more than 1.2 million (PRODUCE 2011). In addition, the CITEs are understaffed having only in average 13 employees per CITE, which is a reduced fraction (4 %) of the average employment in public research institutes.

Although the results of this programme are well regarded by the firms that participate in them, as the evaluation showed, their impact is rather limited. When we

[8] These include: agro-industry; mining and environment; logistics; software; fashion design; textile and apparel; alpaca confections; tropical fruits and medicinal plants and cacao.

consider that Peru is a country with a majority of urban population (i.e. more than two-thirds) and that micro and small firms are the major source of employment, it is hard to understand why this programme was not been extended and upgraded.

5 Impact of Social Policy on Science and Technology Policy

5.1 Background

The economic reforms pursued in Latin America during the 1990s were implemented with the assumption that they would have some impact on poverty alleviation of vast sections of the population. Macroeconomic stability and well-functioning markets would improve economic efficiency through a trickle-down economics mechanism, and the effects would be extensive to poor people. However, empirical evidence showed that this was not the case. Poverty alleviation became an objective in itself in most of the countries of the region.

In the 1990s, poverty alleviation strategies began to be delineated based on the results of specific programmes implemented in the region. Usually, these strategies included programmes to reduce poverty that included actions to generate economic and productive opportunities for poor people; and to alleviate poverty such as the reduction in chronic child malnutrition; the increase in coverage of health services and the improvement of education.[9] These actions were meant to address medium- and short-term needs associated with poverty perpetuation.

By 2005, there were 49 programmes at work with a total budget of US$1,209 million (see Table 2). However, this large budget that represented around 25 % of the total government budget was not displaying the expected results. In fact, most of the nutrition improvement programmes for children suffered from a high degree of filtration and a poor focalisation of the target population. The same occurred to some infrastructure provision programmes in which political considerations were prevalent over technical ones. It is important to highlight that the poverty alleviation programmes budgets were more than tenfold the research and development investment (i.e. US$104 million for 2004).[10]

[9] Verdera (2007) proposed 4 different types of poverty related policies. Poverty eradication policies are aimed at eliminating poverty, to eliminate the number of poor people. Poverty alleviation policies are meant to support vulnerable population via social assistance programs, which can be temporal or permanent. Extreme poverty programs are aimed at eliminating extreme poverty. Overcoming poverty policies increase opportunities for poor people via access to education, health and infrastructure.

[10] Many of the arguments against the increase of STI budgets were that compared to poverty alleviation the former were not critical for improving economic development. In addition, the programs that concentrated most of the allocated budget for poverty alleviation were those that attended short-term needs of the poor population.

Table 2 Number of programmes and executed investment in poverty alleviation and reduction

Sector	Number of programmes	Executed investment (US$ million)
Health	8	132.59
Education	5	99.15
Nutrition	14	353.21
Household welfare	3	150.36
Social infrastructure	6	194.40
Employment and productive development	7	100.41
Natural resources	3	53.69
Roads, rural electrification and communications	3	124.75
Total	49	1,208.56

Source Vásquez and Franco (2007), p. 20

Table 2 also shows that poverty reduction programmes, mostly Education and Employment and Productive Development ones, represented only 17 % of the executed investment, thus showing that the overall poverty strategy did not prioritise the strengthening of capabilities, which may show results in a medium and long-term period but would secure the poor population to be better prepared to overcome poverty.

There was consensus that one of the most effective ways of reducing poverty was to provide the poor population with access to markets. Development agencies began to develop different approaches to facilitate access to markets. One of the most ambitious efforts made by the UK Department for International Development (DFID), Swedish SIDA and the Swiss Development Cooperation (SDC) resulted in the approach Making Markets Work for the Poor (M4P). The idea was that the poor are dependent on market systems for their livelihoods, thus changing those market systems to work more effectively and sustainably for the poor will improve their livelihoods and consequently reduce poverty. The approach highlighted the role of economic growth as the most important contributor to poverty reduction. Critical factors to foster economic growth were, on the one hand, markets for goods, services and commodities that operate effectively for everyone but especially the poor as consumers, producers or employees. On the other hand, basic services such as education, health and water that can build people's capacities to escape poverty.

The M4P approach stated that markets are far more complex than punctual transactions between buyers and producers. M4P envisions markets inserted in a system of institutional structures and incentives that define their performance. On the one hand, there are norms and regulations that influence performance and rules for entry, exit, operations and business behaviour. On the other hand, there is a set of support functions that favour the markets' work and interaction with norms.

One of the most important development tools within the M4P approach was the development of value chains. They describe the full range of activities required to

bring a product or service from conception, through the different phases of production (involving a combination of physical transformations and the input of various producer services), delivery to final consumers and final disposal after use (Kaplinsky and Morris 2001). Although value chains are usually identified with a demand focus, there are some doubts if this focus is maintained during the implementation of projects. In fact, the M4P approach looks for eliminating bottlenecks found in the functioning of local markets that impede that products reach the final markets.

A slightly different approach was suggested by Riordan (2007) who suggested that projects should focus on market chains rather than production chains. Thus, projects should begin by identifying actual buyers (i.e. with name and last name) and later work in finding agents that would help connect producers with these buyers. This approach was extensively used by projects promoted by the US Agency for International Development (USAID).

5.2 Social Inclusion Programmes that Promoted Technology Transfer for the Poor

Production chains that articulated poor producers with markets were introduced as early as 1964 by the SDC. In that year, a project providing technical assistance for the production of cheese was launched by the SDC. The project had a supply approach because it focused on the resource endowment of certain Peruvian towns and tried to promote an activity that may foster economic dynamism. The project also identified clients to secure a market for the cheese.

In terms of technology transfer, not only Swiss cheese production techniques were transferred but also techniques for raising cattle, for the production of feeding forage and for the production and handling of milk. Project results included technological assimilation and adaptation due to consumers' preferences. Consumers were not very fond of Swiss cheese and it did not have acceptance in local and regional markets. Thus, some modifications were made to the technology to be transferred resulting in a new type of cheese that was called Andino cheese. So far, this cheese has become the typical cheese produced in Andean towns (Kuramoto 2011).

SDC also launched another programme to articulate poor producers with markets. PYMAGROS was implemented in the period 1996–2005 with a budget of US$7 million. The programme had 3 strategic lines: (a) to identify market niches at the regional, national and international level for producers from Cajamarca, Cusco and Apurímac;[11] (b) to help small producers' organisations to overcome

[11] These 3 regions are among the poorest in Peru. According to the Regional Competitiveness Index 2011, Cajamarca ranks as the 24th region from 25, falling 2 positions from 2010; Cusco ranks in the 12th position, falling 2 positions from 2010; and Apurímac ranks in position 23 (CENTRUM 2012).

their limitations; and (c) to promote the adaptation and diffusion of technological innovations for market with potential growth.

The project developed tools for technological transfer in products such as paprika, organic products, yacon,[12] purple maize[13] and Cusco's giant white maize. PYMAGROS also supported the protected designation of origin (PDO) process for the Andean product of the Cusco's white giant maize. This demanded to establish technological standards and the definition of best practices in the crop management. Being a programme to eradicate poverty, the internal evaluation of the project was more focused on its impacts on income increase, gender equality and increased production. The evaluation also focused on increased capacities having as an indicator the strengthening of producer associations.[14]

In 1996, the SDC launched another project, The Innovation and Competitiveness of the Potato, also known as the INCOPA Project, which was formulated with a stronger focus on innovation and competitiveness, although it was targeted to poor Andean peasants and it was almost meant to eradicate poverty. This project was implemented in Bolivia, Ecuador and Peru and was aimed to introduce in the market non-traditional species of potatoes that were cultivated by peasants for their self-consumption. The project developed several new products (i.e. snacks, instant mashed potato mixture, etc.) that helped increase the demand of native potatoes and, as a result, increase the income of peasants.

The project required that an international research centre (i.e. The International Potato Centre—CIP) perform some R&D to develop an innovation product that would be transferred to the peasants.[15] The project also developed social innovations along all the value chain, for example, to secure peasants procure the shipments of potatoes demanded by the market, as well as in the commercialisation link to improve the handling of bulk potatoes.[16]

The INCOPA project set a new standard for projects aimed at articulating poor producers with dynamic markets. Technological innovations and their transfer became one critical point in these projects. Field work demonstrated that

[12] Yacon is an indigenous root that contains an especially healthy sugar that is not digested by the body and therefore yacon does not elevate blood glucose levels making it safe for diabetics and weight watchers.

[13] Purple maize is typical from Peru. It is the main ingredient for a traditional beverage called purple chicha and a dessert made out from this beverage (i.e. purple porridge). This maize is rich in anthocyanins (also known as flavonoids), which are reported to have anti-diabetic properties. There is some evidence that purple maize helps lower blood pressure, reduce inflammation and protect from cancer.

[14] The SDC did not publish any evaluation report of this project, although there are some internal documents that provide some findings about the performance of the project.

[15] For example, the CIP developed potato seeds that would secure a longer shelf life in the supermarkets.

[16] Stevedores in the Lima wholesale market agreed to change the bulk weight of potatoes from 75 kg to 50. This reduction in weight increased the efficiency of handling and reduced the risks of occupational injuries.

technology could be a powerful means to achieve governance in value chains such as Kaplinsky and Morris (2001) suggested.[17]

Some lessons learnt from this project were that, first, a participatory approach is required to create and/or strengthening value chains[18] This approach resulted in new rules of collaboration among the actors in the chain (i.e. institutional innovations), more efficient processes (i.e. process innovations), or new products (i.e. product innovations or commercialisation innovations). Second, for innovations to be realised, a demand focus is required. Thus, consumers were the leading actors in this process. Consumer demands for innovation were translated to previous links' actors in the chain (Devaux et al. 2006).

Another important project aimed at developing production chains that had a major technological impact on Peru was the USAID Poverty Reduction and Alleviation Project (PRA). The goal of PRA "was to contribute to poverty reduction by generating sustainable income and employment and mobilizing private-sector investment in key economic corridors of Peru, defined as natural commercial networks linking rural areas with intermediate cities that exhibit high rates of poverty and the potential for economic growth" (Chemonics International Inc 2008, p. 1). USAID PRA included two main components: business services, through regional economic service centres (ESCs), which assisted individual client firms to overcome specific obstacles to business expansion; and public–private partnerships that helped leverage funds for key transport infrastructure development.

USAID PRA helped develop various production chains including: trout, palm oil, flowers, rice, ceramic tiles, poultry, milk, tara, coffee, wood, bixin (i.e. achiote tree seeds used for food colouring) and fruits. Cumulative sales for the period 2000–2008 reached US$307 million and meant the creation of 81.9 thousand permanent jobs.

USAID PRA transferred technology that caused structural change in specific locations. For example, new industrial activities with higher returns such as advanced technology in the production of ceramic tiles and trout processing increased productivity in their respective production sites. But they also increased productivity in primary agriculture as new crops were introduced (i.e. introduction of artichokes) or new demand for traditional crops induced changes in agricultural practices (i.e. snack industry demands specific potato varieties). All technology transfer was aimed at meeting rigorous standards that specific chains had to meet to enter final dynamic markets, whether they were domestic or international. In fact, US$141 million of sales were directed to markets such as the United Stated (38 %) and the European Union (35 %), which required different kinds of certifications.

[17] Kaplinsky and Morris (2001) highlighted the important role of standards in achieving governance in value chains. They mentioned three levels of governance. First, one level is defined by the basic rules that are to be met to participate in the value chain. Most of these rules are related to standards that secure quality and specific industry standards (i.e. phyto sanitary and HACCP). A second level is related to monitoring and securing the compliance of those basic rules. A third level refers to establishing the mechanisms to help producers meet the standards.

[18] The INCOPA project focuses on creating new value added rather than just strengthening an existing production chain.

USAID PRA's technical assistance was not defined beforehand. It was a means to achieve the three objectives set for every promoted production chain: new sales, new jobs and investment. Thus, technical assistance was really demand-driven, avoiding in this way supply side solutions not supported in actual sales.[19] Another difference found with regards to other development agencies' projects is that USAID PRA supported projects promoted by large firms as opposed to the other agencies that had a preference to promote projects in which small and medium firms participate. The argument used by USAID PRA is that larger firms are the ones that have purchasing power and are more capable of articulating demand and supply. In fact, around 219 large firms created markets for the goods produced by more than 42,000 small businesses, growers and producers (Riordan 2007).

The success of USAID PRA became a model for other similar projects. In fact, USAID, together with the Government of Peru's Sierra Exportadora,[20] Minas Buenaventura, and Antamina, formalised an alliance to fully embed the PRA approach in the Sierra of Peru. It is expected that the joint efforts of these entities will diffuse a model of intervention that comprises development agencies, state organisations and the private sector.

The experiences of these poverty eradication projects that used the production/value chain approach and that stressed technology transfer set up a model that was used in specific technology-oriented projects such as INCAGRO, which was described in Sect. 4.

6 Conclusions

During the last 15 years, there has not been a direct connection between the Peruvian STI and social inclusion policies, although there are some major policy statements that declare that the former should contribute to human development. This is not just the result of separate policy areas that do not coordinate actions. It is more the result of weaknesses in the innovation system that reduce the governance of the whole system and impede that it function effectively.

Just like everything else, the STI policy arena has been influenced by new ideas, approaches and models in the last 50 years. Empirical evidence of what worked well in advanced countries and in those that were successful in catching up shaped policy recommendations that should be followed by countries that wanted to

[19] USAID PRA project rests on Riordan's (2007) philosophy: "supply-pushed thinking leads people to try to sell what they produce, whereas demand-driven thinking leads them to produce what they can sell" (page 51).

[20] Sierra Exportadora was created in 2006. Its mission is to promote and develop economic activities in the Peruvian Andean region to help producers articulate with domestic and international markets. In its first years, Sierra Exportadora received various critiques, such as its lack of capacity to articulate with other government programs as well as its blown up goals. Sierra Exportadora's stakeholders welcomed the strategic alliance with the USAID PRA project.

experience a similar success. International organisations had an important role in designing and diffusing new policy proposals to less advanced countries.

However, no matter how good these intentions were, less advanced countries were usually not ready for new policy ideas. As a result, the latter were implemented without having the necessary conditions to put them into operation and, most of the time, these new policy options did not work properly.

Peru was not the exception. It received influences from different development and bilateral agencies to implement new policy ideas that implied the construction of institutional frameworks that later did not work properly. That was the case with the setting up of a science and technology system during the 1970s. It became a centralised system without adequate funding and with a supply-side emphasis, unable to articulate the scientific and technological needs of the productive and social sectors with the meagre knowledge that was produced in the country. Twenty five years later, the innovation systems approach was adopted without changing the institutional setting. The result is an innovation system that barely performs any of its ascribed functions and lacks governance, which is reflected in the almost inexistent coordination mechanisms among the components of the system.

As a result, the system can hardly harmonise efforts to achieve national objectives. That is the case of the STI policy and the social inclusion one. Even though the National Plan for Science, Technology and Innovation for Competitiveness and Human Development declares that science and technology should be at the service of human development, there is no single indicator or mechanism within the plan that clearly addresses human development issues.

However, some technology transfer actions subsumed in poverty alleviation programmes were able to strenghten production chains and conglomerates. Those were the cases of the Innovation and Competitiveness Programme for Peruvian Agriculture, the INCAGRO Project; and the network of Technological Innovation Centers (CITEs) run by the Ministry of Production. These two projects were implemented in complete independence from the STI system. According to their respective evaluation reports, both programmes were positive. The INCAGRO project had better and more impressive results, while the CITEs programme needed more funding to increase its coverage and upgrade the services it offers.

On the other hand, social inclusion programmes had a huge impact on strengthening production chains via technology transfer. After their experience with different projects, development agencies decided that one of the most effective ways of reducing poverty was to provide poor population access to markets. The promotion of productive/value chains became the prime strategy to achieve that goal.

Different development agencies, such the Swiss Development Cooperation and the United States Agency for International Development (USAID), have funded major projects in Peru to promote different production chains with the aim of articulating poor rural producers with dynamic markets, domestic and international. One key element of such production/value chains was technological governance to secure the quality levels and requirements asked by markets. Thus, without intending it, social inclusion projects and programmes had a great impact on technology transfer and on the diffusion of best practices.

The success of such social inclusion projects might be attributable to a strong demand-side focus. As a USAID sponsored programme proclaims, it promotes production that can be sold, instead of trying to sell what is produced. This is opposite to the usual focus with which STI programmes are designed in Peru. The overall vision of the STI policies needs to prioritise demand. That requires changes in this system to guarantee its governance and to set the adequate incentives to induce the different actors to mobilise resources and execute science, technology and development activities that would deliver goods and services demanded by all kind of consumers. In a country with a large population with huge needs, science and technology must definitely be at the service of those needs, not just in paper but in real terms.

References

Agraria Agencia de Noticias (2011) Salida de INCAGRO condicionaría apoyo del Banco Mundial. http://www.agraria.pe/noticias/salida-de-incagro-condicionaria-apoyo-del-banco-mundial

Arocena R, Sutz J (2002) Innovation systems and developing countries. DRUID Working Paper 02–05. Danish Research Unit for Industrial Development, Copenhagen

Arocena R, Sutz J (2005) Innovation systems and developing countries. DRUID Working Paper 02–05. Danish Research Unit for Industrial Development, Copenhagen

Brown H, Tellez T (1973) National Academy of Sciences: International Development Programs of the Office of the Foreign Secretary. Summary and Analysis of Activities 1961–1971. National Academy of Sciences, Washington DC

Economic Commission for Latin America and the Caribbean (2012) Panorama Social de América Latina. ECLAC, Santiago de Chile

Castillo P et al (2008) Limitantes del crecimiento económico. Notas de Estudios del BCRP 1

Centrum (2012) Índice de Competitividad Regional 2011. Centrum Católica, Lima

CEPLAN (2011) Plan Bicentenario—El Perú hacia el 2021. Centro Nacional de Planeamiento Estratégico, Lima

Chemonics International Inc (2008) PRA Project Work Plan—Fiscal Year 2008. USAID, Lima

CONCYTEC (2005) Plan Nacional de Ciencia, Tecnología e Innovación—Ciencia y Tecnología Para la Competitividad y el Desarrollo Humano Sostenible. Consejo Nacional de Ciencia, Tecnología e Innovación Tecnológica, Lima

Cooper C (1999) National Systems of Innovation: The institutional framework for technological learning in developing countries. Paper presented at the Creating a New Architecture for Learning and Development Conference, Asian Development Bank, Tokyo

Devaux A et al (2006) Papa Andina: Innovación para el Desarrollo en los andes, 2002–2006. International Potato Center, Lima

Dias A et al (2010) Impacto de la Inversión Pública en I&D+i Agraria en Perú: la experiencia de INCAGRO. INCAGRO, Lima

Eguren F (2006) Reforma agraria y desarrollo rural en el Perú. In: Eguren F (ed) Reforma Agraria y Desarrollo Rural en la Región Andina. CEPES, Lima, p 11–31

Finnemore M (1993) International organizations as teaching of norms: the United Nations Educational, Scientific and Cultural Organization and science policy. IO 47(4):565–587

Freeman C (1987) Technology Policy and Economic Performance: Lessons from Japan. Pinter, London

Freeman C (1995) The 'National System of Innovation' in historical perspective. Camb J Econ 19:5–24

Gu S (1999) Implications of National Innovation Systems for Developing Countries: managing change and complexity in economic development. Discussion Paper Series 9903. UNU-Intech, Maastricht

Hekkert MP et al (2007) Functions of Innovation Systems: A new approach for analysing technological change. Technological Forecasting and Social Change 75(5):413–432

Intarakumnerd P et al (2001) National Innovation System in Less Successful Developing Countries: the Case Study of Thailand. Res Policy 8–9:1445–1457

Kaplinsky R, Morris M (2001) A Handbook for Value Chain Research. IDRC, Sussex

Kuramoto J (2011) La articulación productiva: desafío para un país inclusivo. La cooperación suiza y la articulación productiva rural. Agencia Suiza para el Desarrollo y la Cooperación (COSUDE)/Consorcio de Investigación Económica y Social (CIES)

Mayorga R (1997) Closing the gap. No SOC–104. Department of Social Programs and Sustainable Development—IDB, Washington DC

National Academy of Sciences (1967) Second Peru - US Workshop on Science and Technology in Economic Development. National Academy of Sciences, Washington DC

OECD (2011) OECD Reviews of Innovation Policy: Peru 2011. OECD

Preissing J (2012) INCAGRO: Developing a Market for Agricultural Innovation Services in Peru. In: Agricultural Innovation Systems: An investment sourcebook. World Bank, Washington DC, p 240-245

PRODUCE (2011) Estadísticas. Lima: Ministerio de la Producción—Comisión Nacional para el Desarrollo de la Micro y PEqueña Empresa (CODEMYPE)

Riordan J (2007) One buyer at a time. SSIR 5(1)

Rosebloom J et al (2006) Reforma institucional de la investigación y extensión agrícula en América Latina y el Caribe. En Breve 90:1–4. http://siteresources.worldbank.org/INTENBREVE/Newsletters/20946748/90-MAY06-AgInnovation-SP.pdf

Sierra P (2012) Evaluación del Modelo Centros de Innovación Tecnológica CITE—Informe Final. IDB, Lima

The Conference Board (2013) The Conference Board Total Economy Database™. Summary Statistics 1996–2013. The Conference Board, Groningen. http://www.conference-board.org/retrievefile.cfm?filename=SummaryTable_hc_Jan152013v21.pdf&type=subsite

The World Bank (2005) Implementation completion report (TF-27087 SCL-45190) on a loam in the amount of US $9.6 million to the Republic of Peru for an agricultural research and extension project. Report No: 34521. World Bank, Washington DC

UN Millennium Project (2005) Applying Knowledge in Development—Achieving the Millennium Development Goals. Science, Development and Innovation Task Force. Earthscan, London

UNCTAD (2011) Science, Technology and Innovation Policy Review: Peru. UNCTAD, New York/Geneva

Vásquez E, Franco M (2007) Fusión de programas sociales en el Perú: Un fondo de inclusión social como propuesta. Discussion document DD/07/03. Universidad del Pacífico, Lima

Verdera F (2007) La pobreza en el Perú: un anáisis de sus causas y de las políticas para enfrentarla. Series Economic Analysis 24. Instituto de Estudios Peruanos, Lima

Weyland K (2005) Theories of policy diffusion: lessons from Latin America pension reform. World Polit 57:262–295

Weyland K (2009) Institutional change in Latin America: external models and their unintended consequences. Journal of Politics in Latin America 1:37–66

Value Attributed to STI Activities and Policies in Uruguay

Carlos Bianchi, Mariela Bianco and Michele Snoeck

Abstract This chapter discusses how STI activities are valued in social, economic, and political contexts in Uruguay. After reviewing recent political changes in the STI sphere, different information sources are used to trace out preliminary features concerning the public's perception of the value of STI, as well as the value attributed to technology and innovation in production sectors. In this way, we address the issue acknowledging that this is a relevant aspect of policy-making. This article highlights the fact that in recent years, Uruguay has undergone a process of political revaluation concerning STI activities, made evident in institutional changes, budget increases, and greater attention paid to the subject in political discourse. We argue that this revaluation process is not homogenous, as different economic and social sectors perceive and value science, technology, and innovation differently. The general conclusion appears to be that these variations in value attributed to STI are one of the most relevant factors for the design of efficient policy instruments. Some guidance is suggested for further research on the topic.

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1 Introduction

A number of authors point out that in countries that have followed a path of virtuous development, it is possible to observe different indications (political, institutional, social, and economic) of high value attributed to scientific and technological knowledge (Pérez 1986; Fajnzylber 1983; Arocena and Sutz 2003). The basic idea of the theoretical hypothesis, and the historical evidence behind this assertion, is quite simple: Societies that value scientific and technological knowledge more highly will promote the education of individuals, as well as the demand for knowledge concerning different activities of cultural and material production and reproduction.

Social researchers have approached the assessment of social value attributed to knowledge in various ways, especially regarding scientific–technological knowledge. Historical studies assessing the value attributed to arts and sciences exist as do studies assessing the promotion of inventive activities, and more recently, studies have been carried out to define the social perception of scientific and technological activity. Likewise, there are studies dealing with technological demand related to particular sectors or areas of activity. In this chapter, we attempt to define the value attributed to scientific–technological knowledge in Uruguay. This entails a preliminary exploration of the current perception held by different economic and social organisms, concerning the importance of science, technology, and innovation (STI) activities. Specifically, a set of diverse indicators have been applied to analyze the hypothesis that the Uruguayan society is undergoing a process of revaluation of the relevance of scientific and technological knowledge for development. It is argued that this process is not homogenous. Indeed, as made evident throughout this chapter, the perception of the value of this type of knowledge varies depending on the area or sector.

This analysis does not intend to establish a causal relationship between the processes of political and institutional change and the social or sectoral perception of STI activities. Available data do not permit this type of analysis, as the number of interacting factors is high and the referred political changes are very recent, thus inhibiting a causal analysis. Nevertheless, it is important to contribute to the debate on the importance of valuing scientific and technological knowledge in Uruguay, analyzing the available information sources, and discussing the implications of valuing STI activities for the purpose of policy design.

It is worth defining our understanding of "how STI activities are valued" in terms of the three dimensions considered in this article. We understand that a valid approximation of social evaluation of STI refers to an assessment of people's opinion concerning the pertinence of these activities and their impact. Surveys that assess the social perception of science consider general and abstract opinions related to a set of activities called science, technology, and innovation. Another way of approaching the valuation of STI activities is by observing efforts made on the part of production agents to incorporate scientific–technological related knowledge. In this context, evaluation is not made based on an abstract notion of STI and its effects, but rather on a concrete reference to STI activities required or

carried out by production agents and the effect these have on economic activity. The third dimension refers to the value attributed to STI in the political sphere, whether at the rhetorical discourse level, or as expressed in the creation of institutions for the promotion of STI activities, related to investment in financial and human resources. In this case, we find both abstract and concrete factors, and to a great extent, policy consists of creating instruments that make it possible to progress from abstract definitions to implementing concrete measures. It is in this sense that we refer to the value attributed to STI activities in social, economic, and political terms.

We do not intend to define "why" STI activities are either valued or not, for example depending on the extent to which they cause improvement in terms of the economic condition of agents, have an impact on national development, or improve the situation of others citizens. Rather our intention is to find evidence concerning "how" (positively or negatively) STI activities are valued by different actors of Uruguayan society and economy. This is a pertinent question because—although it is unlikely that STI activities would have an a priori negative evaluation—this issue runs the risk of being politically invisible, associated with a lack of valuation due to indifference. Political invisibility can affect the feasibility of deploying knowledge-based development strategies, as proposed in current public policies. In developing countries, STI activities and the promotional policies they need often remain "hidden" to the public agenda. In the context of severe budgetary restrictions, resources usually are assigned to areas that are clearly legitimized for public action: education, health, food safety, citizen safety, and—commonly in Latin America—defense. In this sense, while the valuation of an activity by the population or a number of economic or social groups is not a sufficient condition for its legitimization as a public policy, it certainly is a necessary condition.

In Latin America during recent years, there has been a return toward the active participation of the state in a number of policy contexts. In the social area, a debate has taken place concerning the pertinence of certain policies. For example, the conditioned income transfer programs that have become so widespread in Latin America in the last decade are one focus of the debate. Some voices say it is an unnecessary policy with adverse effects—and therefore not legitimate—whereas others defend it as a mechanism promoting equality and development. In contrast, nobody would discuss the legitimacy, relevance, and pertinence of state intervention in education or health, but in this case the matter of debate is how this should be done. In both examples, the valuation of activities and policies is expressed precisely as the diversity of positions being debated, regarding either their pertinence or the way they should be carried out. What is the situation regarding STI policies? As was already mentioned, our hypothesis for the case of Uruguay is that a revalorization is taking place, but this process is not homogenous among the different social and economic agents. There are no recognized voices against the pertinence of STI policies, but these are only seldom publicly debated. Herein lies the risk of these issues remaining hidden—not only policy itself, but also STI activities—and therefore being relegated as a topic for

the community of specialists. It is in this context that we consider it pertinent to contribute to the debate in terms of how the issue of STI valuation in Uruguay should be approached, what does STI mean for different actors, and how can this be translated into policy action.

In the first section of this chapter, we present recent transformations in institutions devoted to the promotion of STI, as well as the growing public budget for these activities in Uruguay. We understand that this makes one indicator of a possible revaluation—at the public policy level—regarding STI. In the same section, we examine certain indicators selected from surveys on the social perception of STI, which to some extent also seem to indicate a positive valuation of these activities by society. In the following section, we analyze aspects related to technology valuation in certain areas of agricultural production, based on empirical results selected from recent studies. In the third section, we also present new empirical results regarding technological demand in specific sectors of the manufacturing industry. This information set is analyzed under the above-mentioned hypothesis, searching to identify "hints" that indicate the ways in which Uruguayan society values science, technology, and innovation. In the conclusions, these hints give rise to a proposed research guideline aimed at directing and deepening the debate on the detected issues.

2 New Institutional Framework, Budgetary Promotion, and Citizen Perception

In recent years in Uruguay, a set of legal, institutional, and economic changes have been implemented in the context of STI promotion policies. These changes have been inspired in the framework of what is intended to be a new development policy where STI activities play a key role. In this context, since 2005, with the arrival of the government of the left-wing coalition *Frente Amplio*, a greater presence in terms of STI in political discourse and programs can be appreciated. An illustrative example is *Uruguay Innovador* ("Innovative Uruguay"), which was one of the programs of this political party when it reached the government. Although it was a general motto, along with six other programs, with a clear electoral function, the appearance of the subject of innovation at a time of elections is a clear sign of a new value attributed to innovation in national policy.

Since the installation of the leftist government, a series of legal and institutional initiatives were actually developed in order to support STI activities, with strong rhetoric emphasizing the impetus given to the development and importance of these activities for economic growth, national competitiveness, and social inclusion. Naturally, it is not that Uruguay based all production and social policies on STI, but rather that STI policy should contribute to these goals.

In 2005, an innovation cabinet was created within the government, purposely for contributing to a new development policy. The cabinet was granted a very high position in the political hierarchy. Based on the consensus that STI issues affect

many areas of activity—industry, health, agriculture, among others—the design was based on the principle of transversality, requiring six different ministries to participate in policy-making. This represented a fundamental change regarding the previous situation, when STI policy was the competence of a Directorate within the Ministry of Education and Culture (MEC by its Spanish acronym). The MEC has traditionally been a ministry with little relative power within the government structure. In the new context, the Ministerial Cabinet for Innovation (GMI) comprises the ministers of the MEC, the Ministry of Economics (MEF), the Ministry of Industry (MIEM), the Ministry of Agriculture (MGAP), the Budget and Planning Office (OPP), and more recently the Public Health Ministry (MSP).

The GMI is in charge of designing and promoting STI policies at a national level. Likewise, the Agency for Research and Innovation (ANII) is responsible for executing policies by applying different instruments and policies. ANII was created in 2007 as a quasi-governmental organization; it acts within the framework of private law, which grants it flexibility to manage funds and human resources. Importantly, this agency has been staffed with qualified management personnel.

There are debates concerning the real division of functions between ANII and the GMI, and the consequences this issue has on policy design and implementation. Regarding the GMI, it is perceived that the attempt to design a transversal form of governance resulted in a lack of clarity concerning responsibilities of the participating ministries. This has left the executing agency with a high degree of autonomy to fulfill functions that extend beyond the management of policy instruments as was initially conceived.

The new institutional framework also included the renewal of the National Council for Innovation, Science, and Technology (CONICYT), which now comprises representatives of more civil organizations than before. This council is in charge of the deliberative level of policies, through its role of adviser to the GMI, the government, and the parliament in topics related to STI. In particular, CONICYT has the legal function to express opinion about ANII's proposals of programs and instruments. Though CONICYT has expressed its willingness to play a more active role than in the past in debating policies and proposing actions in the field of STI, until now its lack of operational resources has restricted its scope essentially to exercising its legal functions with regard to ANII's programs.

Looking beyond design and operational problems, and without denying their importance, this new institutional framework reveals a concern for giving STI issues a higher status in the public policy agenda. By early 2010, the government approved the "National Strategic Plan for Science, Technology, and Innovation" (PENCTI by its Spanish acronym), which established broad objectives and strategic areas.

The building process of the institutional framework ran in parallel with a strong budgetary increase. According to official data, the public expenditure devoted to STI activities presented a more than three times increase during the 2005–2009 period, from almost 37 million dollars to more than 130 million dollars (DICYT-MEC 2012). Those values cover a wide range of activities directly related to the system of science and technology. In addition, other activities related to innovation

and education policies were carried out, for example the so-called *Plan Ceibal*[1] that provides a computer for every child in primary and secondary education. This plan represented an investment of more than 100 million dollars between 2007 and 2009, highly concentrated in 2008 when most of the new equipment was provided.

In sum, the higher value attributed to STI activities in Uruguay is noticeable, among others, in a higher political hierarchy of the responsible organisms, in the hiring of trained and well-remunerated management staff, and in the strong budget increase. However, until now the impact of these changes has been felt predominantly in the community of specialists involved in STI activities, mainly the academic community.

Considering these changes at the political level, the question then arises whether the strong impetus to STI activities concerns mainly the political sphere, or if the higher value attributed to STI has become a characteristic of the contemporary Uruguayan society as a whole, or at least in certain groups. Although at present it is not possible to respond clearly, this question helps us investigating about different types of valuation.

It is difficult to find information that would provide reliable indicators of the degree of social backing of these changes. One possible approach is through the analysis of surveys on public perception of STI. Four surveys of this kind have been conducted in Uruguay. Two of these are not official and were carried out in 1997 and 2003 by an academic researcher (Arocena 1997, 2003). The two official surveys were coordinated by ANII, in 2008 and 2011 (ANII 2008, 2012). None of these followed exactly the same methodology, but some of the results are comparable.

A particularly clear result from the four surveys is the population's ample approval of research activities in Uruguay. When questioned on the merit of scientific research in Uruguay, in all four surveys a large majority expressed to be in favor of such activities and considered them worthwhile (Table 1). As shown in Table 1, the question was formulated differently in each survey, offering distinct sets of answers. Nonetheless, the majority of responses in favor of national research are evident. This majority was considerably larger in the last two surveys than in the first two.

The perception of the national capabilities to carry out scientific research, referred to in Table 1, could be the result of the generalized positive perception of scientific activities, which appears as a trend in the last three surveys (Table 2).

The positive perception of national research does not refer only to its quality or the relevance of doing this, but also to its usefulness. When asked, in 2003, about the applicability of results obtained by Uruguayan scientists, 90 % of people consulted expressed a positive view. When surveyed, in 2008, as to whether research is useful for the country, 78 % responded that it is useful, while in 2011, 56 % responded that research is very or quite useful for the needs of the country (Arocena 2003; ANII 2008; and DICYT-MEC 2012).

[1] Educational Connectivity Plan for Basic Computing for Online Learning, created in 2007.

Table 1 Perception of Uruguay's research potential

1997[a]	Scientific research can and should be carried out in Uruguay	Scientific research can be carried out but should not (excessive costs)	Research cannot be carried out in Uruguay	Do not know/Do not answer
	55.0 %	25.0 %	9.0 %	11.0 %
2003[b]	Research should be carried out with our own resources because the benefits will surpass the expenses	National research should not be promoted because the expenses will surpass the benefits	Research cannot be carried out in Uruguay	Do not know/Do not answer
	51.0 %	28.0 %	13.0 %	8.0 %
2008[c]	Uruguay can develop its own scientific research	Uruguay can develop its own research, but it is not worthwhile	Research cannot be carried out in Uruguay	Do not know/Do not answer
	80.1 %	5.4 %	4.3 %	10.0 %
2011[d]	Uruguay can develop its own scientific research	Uruguay can develop its own research, but it is not worthwhile	Research cannot be carried out in Uruguay	Do not know/Do not answer
	7.4 %	12.6 %	4.1 %	9.7 %

Source [a]Arocena 1997
[b]Arocena 2003
[c]ANII 2008
[d]Author, based on data from the II Survey on the public perception of science, technology, and innovation

Table 2 Benefits of science and technology are greater than the negative effects

	Strongly agree (%)	Agree (%)	Neither agree nor disagree (%)	Disagree (%)	Strongly disagree (%)	Do not know/ Do not answer (%)
2003[a]	10.7	66.7	–	14.0	0.7	8.0
2008[b]	20.0	42.5	13.7	9.8	0.9	13.1
2011[c]	20.5	48.1	21.2	7.6	1.4	1.2

Source [a]Arocena 2003
[b, c]Author, based on data from the I and II Survey to define public perception of science, technology, and innovation

Altogether, these three indicators highlight that in Uruguay STI activities are viewed favorably by society, both at a general level and in terms of their national relevance and usefulness. However, it is worth considering whether this attitude is based on a general friendly perception of STI, or whether these are informed responses. Likewise, it is worth asking the question of how this favorable perception is translated into a proactive attitude toward STI activities.

The data from the 2008 and 2011 surveys, which indicate a more favorable citizen's perception of Uruguay's potential derived from research, should be read with caution. In both cases, a little over 70 % of the population surveyed declared themselves either little or uninformed on the subject of science and technology. In this regard, we propose the hypothesis that this subject has a certain level of citizen support, which is not based on knowledge but rather on a generalized perception that STI activities are positive for the country.

Also, the data show that although there is a favorable perception of STI issues, these are not considered priorities when the question refers to where the state should invest more. In the 2008 and 2011 surveys, the priority turned out to be issues related to social services and security. As might be expected in this kind of survey, urgent social problems are usually prioritized regarding other topics, which are seen to be more distant or less urgent. It is worth pointing out that in this aspect citizen opinion seems to be aligned with government action. Indeed, despite the huge public budget increase for STI activities in Uruguay, this budget is still much lower than the funds assigned to social policies, education, or health.

The value attributed to science and technology in the production sphere is dealt with in the following sections of this chapter, where we further investigate the hypothesis of the heterogeneous nature of value attributed to STI in Uruguay.

Coming back to political aspects, from 2008 to 2011 ANII implemented around 74 million dollars, starting from 5.5 million dollars in 2008 and reaching 29 million dollars in 2011 (ANII 2008–2011). Looking at the 2011 budget structure, more than 60 % was implemented in research-related activities: post-graduate education (National Scholarship System), monetary incentives for active researchers (National Researchers System), and grants for research projects (several special funds). The resources assigned to innovation activities conducted by private firms or by alliances between firms and research institutes, represented approximately 25 % of the 2011 implemented budget (ANII ISA 2011).

This result has been understood as a marked contrast between the success of research policies regarding those oriented to business innovation. It is worth noting that these data are not surprising. Science and technology policies based on promoting research are known since the second half of the twentieth century and are relatively simple to implement when based on excellence and plurality criteria. In contrast, explicit policies for innovation are more novel worldwide and more difficult to implement. In addition to their knowledge creation side, they request the articulation of economic and regulatory aspects, including the management of different types of risk.

In Uruguay, trained administrative personnel and resources are available for implementing both research and innovation policies. The difference between these two cases does not relate to this aspect or to the greater relative complexity of either area. One of the main explanatory factors of the different proportions of the budget destined to these two areas is that research policy is claimed by an active community, which is organized as such and acts collectively. Uruguay's research community participates actively in defining the science and technology programs. Likewise, this community has become increasingly accustomed to competitive calls as the way to access research funds, and researchers are notoriously proficient in formulating effective demands for existing programs. It is sometimes argued that the academic community has developed a capacity to capture STI funds. But there is no sound evidence of this and a more convincing explanation is that this phenomenon is a logical response on the part of an academic community that is competent to express demands in face of a sustained process of budget increase.

In the case of innovation policies, the target population—firms—does not consist of groups able to act collectively to express their demands in the field of STI. The potential beneficiaries of innovation programs and instruments have a limited participation in the design stage. Besides, most Uruguayan firms have internal limitations to identify their innovation needs and opportunities, and they have not yet accumulated experience in formulating innovation projects. Doubts have also arisen about the adequacy of some of the innovation programs, especially when considering the idiosyncrasy of Uruguayan firms. Involvement in innovative activities implies risk, not only technical but also economic, and any result happens in the medium or long term. All these factors are somehow reflected in the six innovation surveys carried out during the last ten years in Uruguay; the results clearly show that the propensity to innovate in the industrial and services sectors is low. All this evidence helps us understand the demand side problems of the innovation policy.

In sum, data presented here confirm that the transformation in the political sphere has been accompanied by a proactive attitude from the academic community, which was the driving force of this transformation and the clearest beneficiary of the new policies. However, such a valuation cannot be observed in the same way in innovation-related activities in the production sectors. This last point is developed in the following sections.

3 Perception of the Importance of Technology in Agricultural Production

For more than two decades, Uruguay has had steady policies for the development of agricultural STI activities. Established in 1989, the National Institute for Agricultural Research (INIA) concentrates the greatest amount of resources in infrastructure, research personnel, and financial resources for agricultural STI, based on a robust budget consisting of both public and private funds. Additionally, research activities are conducted in the different agriculture-related fields at the public university (University of the Republic), as well as at specific programs operated by the Ministry of Agriculture, and through a recent fund for innovative undertakings in agriculture, administered by ANII. Specifically since 2005, and consistent with the general process of reorganization and revaluation of policies, agricultural STI policies have been revised. The demand for technological solutions from different agricultural sectors has existed for many years. However, the response from different institutions has not necessarily involved a systemic vision that articulates the various areas in which agricultural related research activities are developed. Recent policies have attempted to articulate more closely the activities of different institutions and to promote a work logic that takes into account the interplay of the economic, ecological, and social dimensions while providing differentiated attention to the different needs of STI recipients. Nevertheless, this process is very recent, thus accomplishments are still vague, and there are problems concerning the implementation of effective mechanisms for mediating between research and production, both in terms of the articulation of needs and opportunities and in terms of the transfer of knowledge and technology.

Agricultural STI has mainly focused on productivity goals aiming at increasing the volume of cattle production and reducing the length of animal production cycles, increasing the production of crops per unit area, improving food characteristics such as shelf life, and reducing the costs for processing industries. Uruguay has the highest R&D&I expenditure as a percentage share of agricultural GDP in the Southern Cone, comparable to that of some developed countries.[2] Recent research indicates that global productivity in the agricultural sector has grown in the last 30 years, accelerating since 2001 to reach a cumulative 4.5 % annual rate. It is estimated that approximately a third of agricultural GDP in 2009 is explained by productivity growth occurring in the last two decades. Part of this growth results from the sector's STI investment (Pareja et al. 2011).

In this context of agricultural productivity improvement, technology is positively regarded by agricultural producers, owing to the fact that it frequently helps improve economic results. However, the influence of technology on other specific social aspects such as employment, training, time spent at work, or occupational

[2] This relationship is largely explained by INIA funding structure, which is nourished by the contribution of the public budget and by an additional tax paid by agricultural producers for the commercialization of agricultural products (IMEBA).

health at the farm level should be cautiously examined. Impacts from STI activities have been limited in these areas because their search from the policy perspective has not been deliberate. Agricultural STI policies have generally conceived social impact as a natural consequence of the productive performance of technology. Among dairy and cattle producers, there is a positive appreciation of STI derived from the view of technological changes in their farms. This opinion is fundamentally associated with economic improvements and the enhancement of working conditions of farm workers. However, other aspects of fundamental importance in terms of social implications, such as the creation of new jobs, training opportunities for workers, and/or collaboration among producers in order to use technology, have not been appreciated by agricultural technology adopters. This situation is illustrated by recent data collected among dairy producers and extensive cattle raisers.[3]

The Uruguayan commercial dairy sector has undergone technological transformations in recent decades, which have influenced the increase in milk production volume, for both processing plants and export (DIEA 2009). At present, the sector involves about 4,500 producers at different technological levels in a process of intensification known as the dairy technological path (La Manna 2008), which has been proposed and adjusted by the institutions conducting agricultural STI activities. In 2011, a national survey of dairy producers collected their opinion regarding the effect of different components of the technological path on a set of social indicators, including aspects of training and employment, health, income, farm management, and administration.

Results from this survey reveal that producers are well acquainted with available technology and willing to introduce changes in their productive practices. The technological package proposed for the dairy sector registers growing levels of adoption with an overwhelming majority of producers having made changes during the last decade (8 out of 10) concerning either the handling of their parcel of land, cattle feed, infrastructure and machinery, and/or herd management. Data show a positive assessment on the part of producers regarding the utility of STI activities directed toward the dairy sector. The set of recommendations referring to land management is the component of the proposed package that producers have most intensely adopted; this includes no tillage, the use of chemical inputs (fungicide and fertilizer) and crop rotation, among others. However, when asked about the main problem faced by the farm, more than a quarter of producers identified technology costs as the main issue, and this was 10 % more relevant for small producers than for the rest. We interpret this result as an indication of the positive appreciation of technology and its central role in production, but which can also become an obstacle in the economic equation for a significant proportion of dairy producers. Consequently, it establishes a challenge for STI policy in order to develop differential technological strategies for different type of producers.

[3] The information is provided by dairy and livestock production surveys within the framework of the study "Evaluation of the Impact of Investment in Research by the INIA for the period 1989–2009" carried out by IICA in 2011 (Pareja et al. 2011).

Undoubtedly, technological recommendations have been widely adopted in agriculture to achieve increasing levels of productivity. The search for better economic returns by applying new methods, inputs, and machinery is indicative of a positive evaluation of the technological dimension. Nonetheless, besides improved economic returns, producers indicate only limited social impacts resulting from technology adoption. Improvements obtained in terms of income stability as a consequence of dairy technology incorporation are the indicators most cited by producers in terms of any possible benefits and the ones that gather greater positive assessment. Contrarily, the increasing need to contract services out of the farm is the most evident negative consequence resulting from the incorporation of technology, and producers are critical of the effects derived from the technological package in this sense. Important social effects such as the promotion of new jobs for women and young workers, groups that are traditionally underrepresented in agricultural production, as well as the need for producers to combine efforts in order to implement changes collectively do not register either positive or negative opinions from the producers surveyed. Nor are there changes in terms of exposure of workers to accidents or work-related diseases. Furthermore, when social impacts are taken into consideration, combining varied and multiple indicators in a single assessment measure, results are very weak though positive. These results are the same for producers engaged at different stages of the technological path. This means that producers with different technological levels who have incorporated technological products or practices in their dairy farms value the economic effect, but do not relate other significant social impacts resulting from technology adoption.

In 2011, a similar survey was conducted among livestock producers. Extensive cattle farming occupies more than 70 % of the agricultural area in Uruguay, involving about 38 % of farms (DIEA 2011). In contrast with what happens in the dairy sector, these producers have shown less interest regarding technology, indicating a relatively imprecise knowledge of available technology, and of the way in which changes have been integrated into their production routines. The survey of cattle producers was designed to detect the main technological changes introduced by the producers since 2005 and their opinions concerning social impacts.

The survey results indicate that 7 out of 10 producers made some kind of change regarding techniques in their farms during the 5 years previous to the survey, thus suggesting that as in the dairy sector, there was a positive appreciation of technological propositions. Among the most adopted techniques producers indicated the control of cattle lactation, heifers rearing, strategic feeding and supplementation, grassland improvement, and modifications in the grazing system. Producers' opinion was sought concerning the effect of the incorporation of these changes on labor demand, the need for workers training, the need to associate with other producers, as well as on their own quality of life and their families' as approximate indicators of the social value attributed to technical change.

Regardless of the farm size, there is survey evidence that the workload and qualifications required are aspects that increase with the introduction of new technological practices such as those mentioned. However, this does not translate into new jobs in cattle farming and only becomes partially concretized in training

opportunities for contracted personnel. Contrarily, more than half of the producers indicate that their workload and that of their family members has increased. In fact, having made technological changes most producers state that they have not modified the number of contracted workers. Similarly, 6 out of 10 producers indicated that these changes required better-qualified workers, but half stated that training was undertaken by themselves or some member of the family. Among changes, the main concerns the use of feeding concentrates, changes in the grazing system and changes in cattle breeds. Association with other producers did not seem to be an aspect promoted by the new technological practices as less than a third of the farmers felt the need to associate with other producers in order to use technology.

The survey also sought producers' opinion regarding the impact of changes on their quality of life and that of their families. In this sense, 68 % of those making changes in the last few years judged this aspect as positive or very positive. No significant differences of opinion were found in terms of farm size, or according to the productive system orientation.

Complementarily, producers were asked about the origin of the changes, among which the trust network of the producers, groups integrated by their own peers and the technical staff who advise them, are highlighted as the main sources of influence directing technical changes. Institutions conducting agricultural STI activities do not rank among the options indicated by cattle producers as having the greatest influence in terms of promotion and diffusion of technology for the sector. A consultation with experts on the themes of communication and transfer of agricultural technology, carried out in the context of the same research, detected various criticisms relating to the intermediary role played by STI institutions with producers and users of technology. Opinions are even more emphatic when referring to the specific case of the cattle sector, vigorously indicating the need for improvement in terms of the link between the institutions and the agricultural STI activities as well as regarding the implementation of specific projects designed to differentiate strategies of intermediation in conformity with particular characteristics of producers. In this sense, although the general appreciation of STI is positive, organizations specializing in particular activities in the cattle sector are viewed critically.

In sum, in line with the positive social perception of STI described in the previous section, related to Uruguayan society as a whole, the two agricultural sub-sectors studied also show mainly favorable opinions regarding technological changes implemented in recent years. In general, these opinions relate to improvements in income stability, working conditions, and quality of life. However, technology has not improved opportunities for employment or training of the work force in agricultural activities. Likewise, there appears to be a weak promotion of technology by the organizations associated to the STI policies and activities in terms of efficiently channeling technology diffusion. In this sense, in spite of the fact that the agricultural sector has several mechanisms for articulating production and STI policies, these still appear to be under-used in terms of facilitating technological demands and propositions, which have the potential to produce significant changes

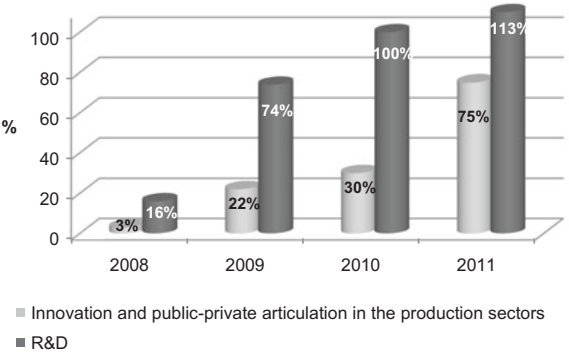
in specific social contexts. It is probably still too early for benefits to be reaped from an orientation, induced by STI policies, toward activities more aligned with the interrelationship that should exist between economic, ecological, and social aspects.

4 Value Attributed to Technology and Innovation in the Manufacturing Industry

In line with a trend at the international level, current STI policy in Uruguay assigns a significant role to business innovation and to liaisons between the production sectors and the academy, as a means for developing competitive advantages and increasing the country's competitiveness. The PENCTI establishes as one of its five objectives, to "increase the competitiveness of the production sectors in the context of globalization." At an operational level, between 2008 and 2012, ANII has placed about fifteen support instruments at the disposal of the business sector, especially for innovation, but also to promote other aspects related to competitiveness, such as entrepreneurship, certification with expected impact in export markets, or articulation of business firms with knowledge-generating institutions. However, the implementation rates of funds assigned to these types of projects from 2008 to 2010 indicate that business demand has not been as expected, in contrast to the case of research support (Graph 1), as was already mentioned in the first section of this chapter. The higher implementation rate of the innovation budget in 2011 was due in large part to the spillover effect of the execution of projects approved in previous years. In 2012, only 49 projects were approved within the component for innovation, competitiveness, and public–private articulation, compared with 74 and 84 in 2011 and 2010, respectively.[4]

A broad analysis of the firms that have benefited from ANII subsidies offers a first view of the value given to technology and innovation in the production sector. ANII's database together with the results of the 2007–2009 national innovation survey in the industrial and services sectors indicate that the profile and innovative behavior of these firms are significantly different from the average (ANII 2011): They invest a greater proportion of their incomes in innovation and R&D activities; they proportionally assign more qualified human resources to innovation activities and show more capacities to develop product innovations; they interact much more with agents of the National Innovation System (NIS); and they manifest better economic performance, measured in terms of evolution of sales and number of personnel employed. The demand for subsidies often stems from young

[4] The demand from 2008 to 2012 consisted of a total of 1,181 projects presented to the different instruments of this component, 30 % of which were finally approved. The lack of innovative merit was the main reason for rejecting projects; other motives included non-compliance of the presentation norms, weakness of the business plan, and negative technical evaluations (ANII 2011).



Graph 1 Implementation rates of annual budgets of ANII, by component. *Source* ANII: POA and ISA 2008 to 2011, www.anii.org.uy

firms and from performing branches of the economy. In brief, firms that value the offer of technological support and win approval for their projects form part of a group of firms characterized as being successful and having a prior "culture of innovation."

The question then arises of the importance assigned to technology and innovation by the silent majority of firms in Uruguay: those that scarcely resort to policy instruments and probably belong to the non-innovative two-thirds proportion of the industrial sector (ANII 2013). Searching for answers to this question, in 2011 an institutional alliance of the "*Triángulo de Sábato*" type—formed by the Ministry of Industry, the Chamber of Industries, and the University of the Republic—financed and executed a pilot project to detect the needs, capacities, and opportunities for technology and innovation in small, medium, and large firms in the metallurgy, food and plastics industries. The results from 80 face-to-face interviews with entrepreneurs indicate some of the present trends in terms of value attributed to STI in these sectors (Snoeck et al. 2011).

Firstly, entrepreneurs consider that they are well informed of recent technological advances in the specialized field of their firms. As most reported advances are in fact incorporated into new or improved machinery, acquiring equipment and automating the process (or part of) is what entrepreneurs desire most—in any of the three considered sectors and for any firm size—in order to increase productivity. They state that the current fluid access to information makes it easy to identify the most adequate equipment and that its acquisition cost usually includes the training of operators. Therefore, in the opinion of the entrepreneurs, the problems presented by modernization and globalization are not technological, but rather consist of assuring, on the one hand, destination markets for the greater volume of production that automation entails, and, on the other hand, access to bland credits that put investment within their reach. Only 20 % of entrepreneurs included some form of knowledge among the different resources they consider necessary in order to achieve technical production improvements.

It is thus clear that a majority of entrepreneurs tend to limit the technology issue to the acquisition of machinery. Eighty percent of those interviewed mentioned that

the first barrier to be overcome in order to reduce the technological gap is the problem of finding financial backing for investment in fixed assets. Only a few interviews made comments such as: "It is not just buying machinery and putting it to work… depending on its use, it can provide many or few results… All these developments require a counterpart in human resources trained for this purpose."

This situation has its corollaries in terms of demand and use of policy instruments. When entrepreneurs were asked about policies that they thought would contribute to solving difficulties in their firm and/or sector, especially in the field of technology, the need for a development bank providing access to credit with preferential rates and terms was a privileged answer.[5] Likewise, tax exoneration—mainly the fiscal benefits promoted by the Investment Law—is the instrument which firms resort to the most. As a general trend, when firms seek support they target essentially cost reduction by way of direct, secure, and immediate benefits, whereas they manifest much less interest in programs that enhance competitiveness with a long-term view and greater risks, such as policy instruments promoting technological development, innovation, or the inclusion of any form of knowledge.

There are also some extreme situations in firms' behavior. On the one hand, some of the visited firms, of different size, have practically no technological projection. In this case, the deliberate objective of entrepreneurs is to survive without major technological upgrading, possibly by acquiring second hand machinery to improve certain stages of the production process. These are often family firms or ones which operate as such, with an excellent relationship between owners and employees and a reasonable position in the internal market. Typically in these cases, the entrepreneur considers that growth—especially through exports—would imply greater costs and problems than the predicted benefits, especially in terms of quality of life. In contrast, there appears to be another group of entrepreneurs who clearly show "industrial vocation." Despite concerns regarding the relative advantages of going on with production in face of the alternative of marketing imported products, these entrepreneurs assume risks, launch costly projects, etc.

Secondly, from the interviews, it is possible to infer that the majority of interviewed entrepreneurs have internalized the innovation concept, either as a means for maintaining or raising competitiveness ("innovate to survive") or in attitudinal terms ("the curiosity and satisfaction of creating new products and solving problems"). It is also worth noting that a large majority of entrepreneurs in the sample were able to report a significant case of product development or product or process improvement in their firm in recent years. Most cases would qualify as innovations following the definitions in the Bogotá Manual. Unsurprisingly, reported impacts mainly included sales increase, higher process efficiency, and/or increase in profits from reduced costs.

[5] Other requested measures included: assisting networking, supporting knowledge for product development and production process improvement, and training.

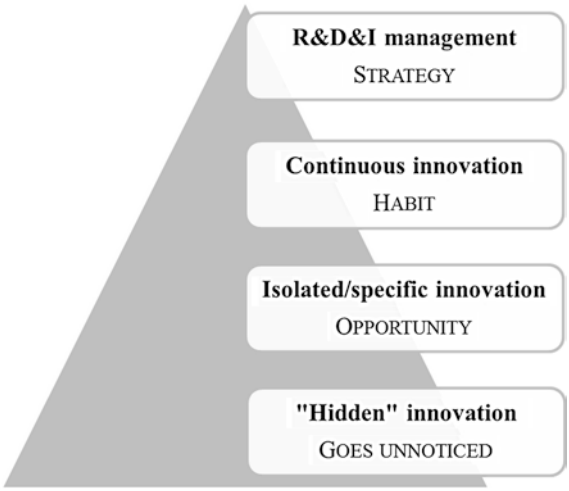


Fig. 1 From innovation as an opportunity to innovation as a strategy. *Source* adapted from Fernández 2008

The analysis of the origin or trigger of these cases of product or process development reveals both proactive and reactive attitudes in firms. Among the first are: the search for opportunities to apply the firm skills to the manufacture of new products (47 % of cases); and the detection of a new opportunity for process and/or product improvement, sometimes related to a latent problem (26 %). The reactive attitudes refer to the response to a specific demand by a client (20 %) or to a concrete process or product problem (7 %).

However, in most cases innovations are punctual (Fig. 1). Generally, it cannot be said that firms innovate within the frame of a knowledge management strategy. Only 16 % of the sample has a strategic or business plan for the coming years that specifically contemplates innovation. Very few firms measure the impact of their innovations by applying specific indicators. Many firms do not have the skills required to innovate continuously, especially at the human resources level. In the plastics sector for example, 56 % of the visited firms do not even have one engineer, and this increases to 88 % of the set of small firms in the three studied sectors. Sixty percent of the visited firms do not assign professionals or technicians to engineering or industrial design activities, a proportion which increases to 92 % in the case of small firms, but is reduced significantly in the most innovative firms. Only 27 % of firms apply a specific problem detection method, whereas 41 % solve problems as they arise.

A third group of observations that provide some hints to analyze STI perception in the industrial sector relate to the importance firms attach to external relationships, especially with a view toward innovation and problem-solving. To start with, interview data allow to distinguish between three different groups of entrepreneurs: The first is reticent to exposing the firm's production problems to external agents as it is considered an internal matter; the second does not conceive of these problems in terms of needs and opportunities; and, in contrast, the

third group of entrepreneurs is keen to put forward concrete issues and needs they face. In the first two cases, problems are encapsulated in the firms; they are neither expressed nor conceived as demands that could be addressed by agents of the NIS. It is thus most likely that these problems will never meet the existing capacities for innovation in the country, and this severely hampers the process of knowledge incorporation in a significant amount of firms. Further evidence is provided by the fact that one-third of the interviewed entrepreneurs (of which 62 % are exporters) bluntly declare that they do not establish contact with other firms or institutions when they face a bottleneck. By gathering this evidence, it is clear that many firms are still locked in on themselves and act in isolation, a behavior that is exactly in the opposite way not only to the current "open innovation" model, but also to any other networking or system-based model.

In contrast with this trend, some of the interviews indicate that when a small or medium firm actively searched for an external actor to share a problem or challenge, the solution ended up involving one or more knowledge-generating institutions, as well as an innovation subsidy or other type of incentive. Similarly, some cases of highly successful user–producer relations were identified, deriving from strategic alliances between local firms and firms abroad. In this sense, fieldwork did not only illustrate once more the need to enhance articulations between the production sectors and the local and global environment, but it also proved that this is feasible and desirable from the point of view of the firm's profitability.

To summarize, in any of the three industrial sectors considered there is a high degree of heterogeneity in the application of STI by entrepreneurs and in their distance from current innovation-based production paradigms. In line with the considerations made at the end of the first section of this chapter, it could be argued that the design of innovation support instruments responded to STI policy objectives without specifically considering the heterogeneous situation regarding value attributed to STI in the business sector. Unsurprisingly, innovation policy faced several problems on the demand side. In another recent research[6] focusing on the lack of cohesion between STI policy design and social science research on innovation processes, interviews were conducted, among others, with policy-makers in Uruguay and other Latin American countries. STI policy-makers clearly recognized that they lack information regarding specific needs and obstacles in the production sectors with respect to innovation. They expressed that this not only hinders the design of efficient policies, but it also makes it difficult to define and communicate research needs to the academy.

[6] The study was part of a regional research project financed by the European Union Seventh Framework Program (EULAKS—Connecting Research on the Knowledge Society in the European Union and Latin America). The study empirical work covered Argentina, Brazil, Chile, Colombia, Costa Rica, Cuba, Mexico, Uruguay, and Venezuela (Snoeck et al. 2010).

4.1 A Policy Initiative Based on the Needs of the Industrial Sector

Considering the evidence supplied by the above-mentioned pilot project, the same three-party alliance (Ministry of Industry—Chamber of Industry—University of the Republic) conceived the design of an industrial extension center as a response to the disconnection between the industrial sector needs and the problem–solution skills in the country. An important aspect to be taken into account was the fact that technological demands of the industrial business sector are not always explicitly expressed, for the reasons previously mentioned. In particular, many small and medium enterprises do not easily identify other technological needs than the purchase of capital goods. Raising productivity is an obvious requirement for competitiveness at a global level, but this need has been strongly accentuated by the ongoing "salary recovery" process in the country, which started in the middle of the last decade.

The proposed industrial extension center includes three components which feed each other (Fig. 2). Briefly, the first consists of a service called "Technical-Competitive Guidance Consultations," aimed at identifying the needs of interested firms, and translating these into demands, initially in the three sectors analyzed in the previous project (metallurgy, food and plastics). The methodology includes, as an element of great importance, the channeling of these demands toward the existing offer of support mechanisms. This guidance service would be provided by high-level teams comprising an

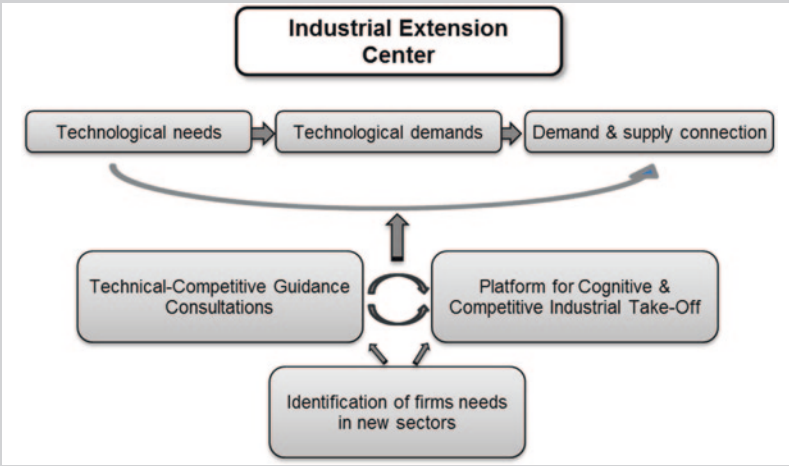


Fig. 2 Conceptualization of the Industrial Extension Center

engineer, an internationalization specialist, a trained expert in the existing policy and services toolbox, and a facilitator.

The second component includes the construction of a Web portal with interactive connection mechanisms between technology supply and demand. On the supply side, this implies significant work in the systematization of existing knowledge and services for each of the industrial sectors involved. Demand would be enhanced by the product of the first component, as well as of the third, which aims at detecting needs in different industrial branches that are prioritized in the industrial development strategy.

In Uruguay, building up and using effectively a Web portal to link technology supply and demand, in a form progressively similar to existing global mechanisms,[7] is a challenge. To ensure the portal's proactive management, an effective liaison with knowledge-generating institutions, etc., the extension center will include human resources specialized in communication and facilitation.

The industrial extension system, which has been conceived essentially as a brokerage mechanism, will develop according to a learning curve with increasing levels of sophistication and territorial decentralization. The initial stage, lasting two years, will establish the system's foundations and launch this new instrument that is intended to systematically stimulate the expression of technological and innovation demands and their articulation with existing capacities in the country. Expected results include the development of more competitive production capacities, especially in small and medium firms that would make a better use of the existing support structure for innovation and competitiveness.

Notably, the framework for this new policy instrument is the current national industrial strategy which addresses, from different angles, the needs and demands of the main actors in the industrial development process. Among others, the present administration leads the setting up and coordination of Sectorial Councils comprising representatives of government, workers, and entrepreneurs. Each part provides its view of the problems that need to be overcome in the corresponding value chain, and together, the three parts prepare an action plan, the execution of which is supported by a new Industrial Fund (Gabinete Productivo 2012).[8]

[7] For example, Innocentive (www.innocentive.com), Innoget (www.innoget.com), or USA Innovation marketplace (innovationsupplychain.com/).

[8] At present, there are twelve Sectoral Councils, in the following fields: automotive, pharmaceutical, wood, naval, apparel, biotechnology, meat, electronics, dairy, metallurgy, construction, footwear, and leather goods.

5 Final Considerations

This article provides a general view of value attributed to science, technology, and innovation by different sectors of the Uruguayan society. As emphasized throughout the text, value attributed to STI activities is not homogenous among social and economic sectors and neither is the use of knowledge by different productive agents.

Based on this general assertion, we can point out a number of stylized facts. In the first place, there is a strong political promotion of STI activities. This is expressed in institutional changes, budget increases, and new political rhetoric. Probably one of the greatest challenges this political initiative faces is to achieve appropriation of the objectives it promotes by all actors concerned, not just the academic community. For now, political transformations evidence a great updating effort, after decades of lagging behind in issues related to application in certain sectors and to institutional inertia in others; but there is yet to appear a reactive impact in different production sectors. The statements made in this chapter show the need for collective discussion concerning the design and performance of the new institutional framework on the one hand, and the adequacy of the current programs and instruments on the other hand.

Secondly, the innovative and technological behavior of the production actors shows a high level of heterogeneity, both in the agricultural sector and in the manufacturing industry. Variations in behavior are also associated with different ways of perceiving technology and experiencing linkages with STI activities and institutions. On the one hand, there is a group of agricultural producers who clearly perceive the relationship between technological improvements, increased production capacity, and growing benefits. On the other hand, in the industrial sector, there is a strong association of technology and production problem-solving with the incorporation of machinery, and a low propensity to resort to other types of innovative solutions. This contrasts with the studied agricultural sectors, where technological changes are related to changes in processes and practices rather than to the acquisition of machinery. These differences may be due to the fact that technological modernization and reconversion processes in dairy production—one of the agricultural sectors studied—started over a decade ago.

Based on these hints concerning value attributed to STI activities in Uruguay, we propose the following summary (Fig. 3) as a possible guide for a future research agenda on the subject.

Figure 3 shows distinct types of hints identified from different sources, as well as the complexity and specificity of the problems that arise in each area; hence, the need to discuss these problems and shed more light on STI activities.

From the above, we deduce the complexity of the challenges faced by STI policy in Uruguay. Probably one of the strongest constraints on policy design and implementation is associated with constraints to influencing agent behavior. It is through attention to this problem that this work intends to contribute to the debate on the importance of value attributed to STI activities in policy-making. To the

	Social environment	Economic environment		Political environment
		Agricultural Sector	Industrial Sector	
Hints	Positive public perception, but not a priority	Long tradition of search for technological solutions	Valuation attributed to technology as capital goods	High value attributed to STI expressed in rhetoric, funds, human resources and new programs
Problems	Uninformed value attributed to STI	Persistent productivist bias	STI understood as acquisition of technical solutions but not as own development	Chronic difficulty to translate the political value attributed to STI into generation of demand for knowledge

Fig. 3 Value attributed to STI on the part of agents and areas. *Source* Author

extent that more information and evidence is created regarding this issue, it will become possible to elaborate some causal structure between policy incentives and agents action.

In any case, current information source limitations do not prevent us from starting to discuss and propose that in areas where agents are not remarkable for their innovative capacity or their high valuation of scientific and technological knowledge, policies should be especially creative. By contrast, in areas with a higher appreciation of STI, policy faces the challenge of deepening its socioeconomic impacts and responding to more diverse needs and demands. This implies that the policy-making process requires being sufficiently flexible in order to identify the technological demands of the agents and to create specific instruments adapted to these needs. The creation of the industrial extension center is a good example in this sense. It is important to emphasize once more the heterogeneity of perceptions and valuations of knowledge in Uruguay and the need to consider this factor in the design of policies and programs.

References

ANII (2008) Encuesta de percepción pública sobre ciencia, tecnología e innovación 2008. ANII, Montevideo

ANII (2008–2011) Plan Operativo Anual (POA). Informe de Seguimiento (ISA). ANII, Montevideo. https://www.anii.org.uy

ANII (2012) II Encuesta de percepción pública sobre ciencia, tecnología e innofación. 2011. Informe de resultados. Colección Inicadores y Estudios 5. ANII, Montevideo

ANII (2013) IV Encuesta de Actividades de Innovación en Industria (2007–2009); II Encuesta de Actividades de Innovación en Servicios (2007-2009). ANII, Montevideo

Arocena R (1997) ¿Qué piensa la gente de la innovación, la competitividad, la ciencia y el futuro? Trilce, Montevideo

Arocena R (2003) Uruguay: ¿Qué piensa la gente en el año 2003 de la ciencia, la tecnología y la innovación? Mimeo, Montevideo

Arocena R, Sutz J (2003) Subdesarrollo e Innovación. Navegando contra el viento. OEI-Cambridge University Press, Madrid

DICYT-MEC (2012) Informe a la Sociedad. Ciencia, Tecnología e Innovación en Uruguay en los últimos años. DICYT-MEC, Montevideo

DIEA (Estadísticas Agropecuarias) (2009) La Producción Lechera en el Uruguay. Serie Encuestas 278. DIEA-MGAP, Montevideo

DIEA (Estadísticas Agropecuarias) (2011) Anuario Estadístico Agropecuario 2011. Serie Encuestas 278. DIEA-MGAP, Montevideo

Fajnzylber F (1983) La industrialización trunca de América Latina. Nueva Imagen, Mexico

Fernández JM (2008) Identificación de la innovación en la empresa: ¿Sabemos que lo hacemos? Paper presented at the III Foro empresarial de innovación en Asturias, PRODINTEC-Fade, Asturias, November 2008

Gabinete Productivo (2012) Plan industrial. Fase 1. Automotor, biotecnológico, farmacéutico, forestal/maderero, naval. MIEM-DNI, Montevideo

La Manna A (2008) El enfoque de INIA en investigación para el sector lechero. Jornada de Actualización Técnica en Lechería: Para una Lechería Eficiente. Serie de Actividades de Difusión 549. INIA, Montevideo

Pareja M et al (2011) Evaluación de los impactos económicos, sociales, ambientales e institucionales de 20 años de inversión en investigación e innovación agropecuaria por parte del Instituto Nacional de Investigación Agropecuaria. Informe Final de Consultoría. IICA/INIA, Montevideo

Pérez C (1986) Las nuevas tecnologías: una visión de conjunto. In: Ominami (ed) La Tercera Revolución Industrial: Impactos Internacionales del Actual Viraje Tecnológico. RIAL, Grupo Editor Latinoamericano, Buenos Aires, p 43–90

Snoeck M et al (2010) Social Sciences Research and STI Policy-Making in Latin America: a Nexus Perception Study. Final report of the Uruguayan contribution to EULAKS project of the European Union

Snoeck M et al (eds) (2011) Capacidades, necesidades y oportunidades de la industria uruguaya en tecnología e innovación. Sectores alimentario, metalúrgico y plástico. Informe final de proyecto. Montevideo. http://gp.gub.uy/sites/default/files/informefinalproyectodni-ciu-csic-25jul2012.pdf

From the Design to the Construction of a Science, Technology and Innovation Policy in El Salvador

Roberto E. López-Martínez and René Hernández

Abstract This chapter is devoted to revise the public policy efforts that have taken place in El Salvador in recent years, which is aimed at the promotion of science, technology, and innovation (STI) as well as the generation of a propitious environment for these activities. Firstly, we review the general situation of the country, the social and economic conditions, and the current STI state. Secondly, the underlying rationale of science, technology, and innovation policy is analyzed within the institutional framework of the country. Additionally, this section includes a detailed description of the institutions and their gradual evolution to better respond to the needs for strengthening the STI system. Thirdly, we examine the main STI policy instruments that have been implemented in El Salvador. Finally, the last section focuses on the conclusions of the study, emphasizing the detected strengths

This work is based on great measure on parts of the UNCTAD/ECLAC (2011a) report; however, recently we have had the opportunity to carry out extensive additional fieldwork, which has allowed us to update the information as much as possible, up to the end of 2012.
We wish to express our appreciation to countless officials from government organisms, businessmen, representatives of the academic sector, and trade associations among others, who granted us interviews for the preparation of this chapter. Special mention is given, for their support in the fieldwork, to Dr. Erlinda Hándal Vega, Deputy Minister of Science and Technology, and Mr. Yax Canossa Humberstone, Director of Technological Development and Innovation. With regard to logistics support, we mention Verónica López of the DIDT. We are also thankful to Marta Pérez Cusó, coordinator of the UNCTAD exam, as well as Cristina Navarrete Moreno, Ana Marta Najarro, and Ignacio del Busto Mellado, officials of the World Bank.

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and weaknesses of the STI policy system, the learning process that has enriched this system as well as the positive aspects concerning institutional redesign and the proposal of new STI policies.

1 Introductory Note: The Notion of Systems in the Literature About Technological Innovation

This chapter takes a relatively heterodox[1] view concerning the referential framework for national systems of innovation (NIS); thus, the focus is more aligned to conditions where the NIS is undergoing an emergence process. This method makes it possible to fulfill two purposes: acts as an analytical model for assessing the operability of a production system in a country defined by an economy of knowledge and also understands the institutional framework that governs STI activities such as a contribution to the design and implementation of plans, programs, and specific policies directed toward improving the operability of a country's production system. In the following, we briefly discuss some related background.

During the evolution of the concept of innovation, particularly during the 1970s, associations began to be established between notions related to systems and innovation, in the works of several academics working with Christopher Freeman and the *Science Policy Research Unit* (SPRU).[2] This phenomenon was portrayed as a *nonlinear process involving the coordinated participation of a wide range of actors*.

Subsequent application of these concepts, during the 1980s and the beginning of the 1990s, was described in three seminal works, which introduced the idea of national innovation systems[3] and implied an extension to the network of agents in the innovation process to include the role played by institutions.[4] The main objective of these *original interpretations*, which did not lead to a unified notion of national innovation systems,[5] was to explain national economic development patterns by analyzing the interaction between participating actors and institutions in innovation networks. Linked to this primary objective, there was also an implicit, and at times explicit, orientation toward the design of innovation policies.[6]

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[1] Albeit orthodox, since it is based on the systems' school of thought, specifically the neurocybernetic view and the viable systems model, see Beer (1972, 1979, 1984).

[2] Andersen (1994).

[3] See Freeman (1987), Lundvall (1992), Nelson (1993).

[4] It is important to emphasize that the concept of institutions refers to the "rules of the game" in the context of nations, in the form of legislation, regulations, uses, customs, etc., and should not be confused with organizations.

[5] The classical reference in this sense is Edquist (1997); see also McKelvey (1991). In addition, the works of original proponents of this concept usually make reference to the differences between the various approaches (Freeman 1995, 2002; Lundvall et al. 2002; Nelson and Nelson 2002).

[6] Dalum et al. (1992).

Despite being oriented toward certain policies, none of the original interpretations included an operative version of the focus on innovation systems. This was fundamentally developed by the OECD, who adopted the notion since the beginning of the 1990s (David and Foray 1994; OECD 1992). This was followed by what we may call a *generalized interpretation* of the approach, which implies that specific national systems may be adequately described by the enumeration of their main components (agents and institutions) that participate in innovation processes and the study of their more relevant interactions. An analysis of the manner in which these interactions give rise to successful innovation systems makes it possible to identify "best practices" and the basic components which then serve as a guide for institutional and organizational learning in the international arena. This generalized interpretation, refined in various reports and studies,[7] is the one that is generally used in innovation system studies.

However, the current interpretation of innovation *systems* is not fully consistent with systems thinking. For example, the approaches have different objectives. The original interpretation of national innovation systems is oriented toward the identification of defining differences in innovative performance in different countries. This particularly considers the way that different national institutions influence the successful performance of innovation systems. Contrastingly, the systems theory is based on the identification of elements, functions, behaviors, etc., which are *similar*[8] in different areas. This implies that systems of any type operate according to the same basic principles, and thus, ideally it should be possible to identify principles that are applicable to specific systems, from those that are more general.[9]

Likewise, the innovation systems approach has been fundamentally based on a traditional definition of systems as entities composed of elements and interactions, and this does not consider aspects concerning the hierarchical structure of systems, treatment of the environment, and the analysis of processes occurring within the system.[10] The open systems theory replaced this traditional notion with one where a system is differentiated from its environment (Checkland 1981; Luhmann 1995; von Bertalanffy 1968) and introduced two pairs of ideas which constitute the basis for systems analysis: emergency and hierarchy as well as communication and control. Thus, new systems arise from the interaction between subsystems, while at the same time, different hierarchies comprising the entirety and its components can be differentiated from the environment. However, these interactions require several communication mechanisms, whose function is to control the system as it *tends* toward stabilization.

The innovation system framework also presents some theoretical paradoxes. One of these concerns the dual perspective of the concept of an innovation system.

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[7] OECD (1994, 1999, 2002), Edquist et al. (1998), Soete and STRATA-ETAN Expert Group (2002).

[8] In a process that goes from perception to analogy and then to isomorphism (Beer 1984).

[9] General Systems Theory (von Bertalanffy 1968).

[10] This is reflected mainly in the debate regarding the appropriate limitations to innovation system analysis.

On the one hand, this is a descriptive framework used to *perceive reality*. On the other hand, a normative posture is adopted and the framework becomes a *model of how reality should be organized*. Thus, instead of being a true representation of observed reality, the result is reality filtered through a predetermined structure. In this way, the national innovation systems approach can only be generalized as an analytical framework which assumes the need for articulation (interactions) between economic agents, but does not provide elements for the systematic treatment of these agents; that is, it does not explain how these can be organized hierarchically in order to form emerging systems of growing complexity.

Consequently, studies carried out within this framework often describe supposed subsystems whose interactions constitute national innovation systems. However, no details are available, allowing us to evaluate whether in reality these agents constitute subsystems, in the sense that industrial or research subsystems are sufficiently mature and developed. Thus, it is generally assumed that these subsystems exist, and thus, it is only necessary to attend to the development of institutions, organisms, political instruments, etc. (through learning/replication of international experiences) in order to promote the interrelationship between these subsystems. Naturally, this approach is relatively successful in countries where for historical reasons, these subsystems effectively exist; however, it will not be very useful in countries where there are no subsystems or where they are still maturing and being consolidated.

Therefore, we suggest that for countries undergoing these circumstances, it is more appropriate to adopt an approach that is closer to systems thinking, permitting both the comprehension of reality and the design of a policy system with the purpose of fostering STI. For this purpose, we initiate by applying the basic principles applicable to any sustainable system[11] and then identify the agents, organizations, and institutions that implement the functions and processes that enable systems to be viable, as well as those not implemented or inadequately implemented. In this way, it is possible to progress toward organizational and institutional design recommendations, making a more efficient operation of the system possible. The above implies the need for and utility of distinguishing two *hierarchical dimensions* for the operation of the NIS: *execution*, corresponding to the way in which various economic and social agents converge for the creation, diffusion, and application of knowledge, and *normative*, which corresponds to the way in which public policy facilitates, regulates, and promotes the harmonic operation of agents participating in innovation processes.

The following functions are implemented as part of these two dimensions: production or execution, regulation, management or control, foresight and cohesion, where the last four refer to normative aspects. In this sense, the system as a whole is able to react in the face of events related to the environment, both immediately and in the long term, making it possible to maintain its identity within a shared environment (sustainability). From another perspective, STI policies and their interactions with parts of the economic system are interpreted as constituent components of a system of this type, where the functions of cohesion and foresight will correspond to

[11] Ver Beer (1972, 1979, 1984).

the governance and design of STI policies, and the functions of control and regulation will correspond to the administrative and regulatory framework inherent in the activities of science, technology, and innovation, also acting as a link to the execution system (creation, diffusion, and application of knowledge).[12]

The following section is dedicated to the analysis of conditions in the environment and in part to the system of execution in El Salvador—without referring to industrial chambers, support organisms, or the financial system (the latter will be briefly revised in Sect. 4.4). Later on, in Sects. 3 and 4, we will focus on the description and analysis of the actors responsible for the functions of cohesion, foresight, control, and regulation in the country.

2 The Environment Surrounding STI Activities in El Salvador

2.1 Performance and Evolution of the Salvadoran Economy[13]

2.1.1 Macroeconomic Performance

El Salvador, the smallest and most densely populated country in Central America, is the fourth economy of the region in terms of GDP and the third economy regarding income per capita (3,430 dollars), after Costa Rica and Panama. In terms of human development, El Salvador is situated in ninetieth position according to the 2010 Human Development Index, also behind Costa Rica and Panama (Table 1).

Over the last two decades, El Salvador has implemented a set of liberal economic policies with the objective of developing an open economy and reaching a macroeconomic balance. A set of structural reforms have been carried out, including an important privatization and liberalization process for the financial, electrical, telecommunications, and pension system sectors. In 2001, the Salvadoran economy was dollarized with the objective of promoting stability for investors, reducing inflation pressure and lowering real interest rates. Several free trade agreements have also been signed with Colombia, Guatemala and Honduras, the United States, Panama, Mexico, Chile, and Taiwan. The Salvadoran government has also promoted a prudent tax policy.

These structural reforms and economic policies have promoted development, promising significant economic services in the country, diversification of the economy, and a certain degree of macroeconomic stability, with controlled inflation rates, but they have not achieved robust or balanced economic growth (Graph 1).

The main reason for the poor results is found in low investment rates and national savings. El Salvador consumes more than it produces. Income from family

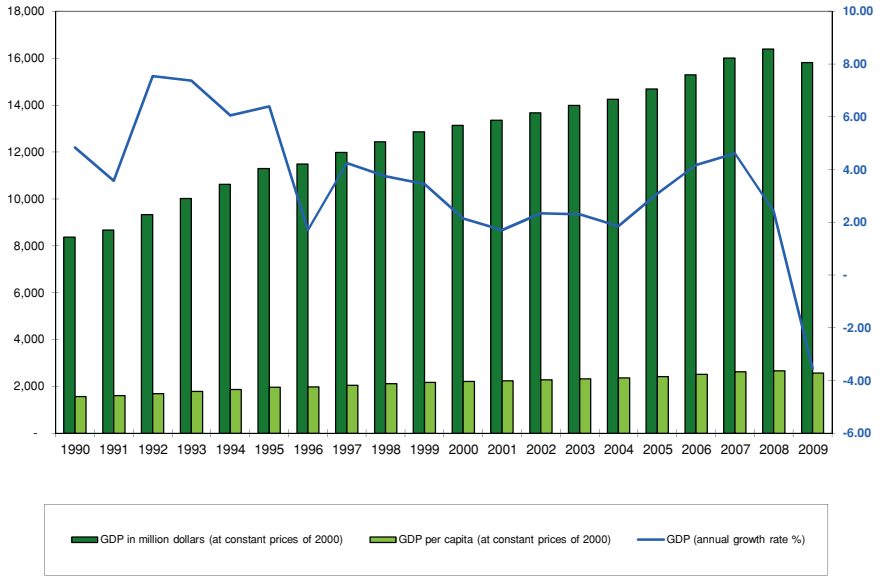
[12] For more details on this approach, see Lopez-Martinez (2010) and his application to the UNCTAD/ECLAC STI Policy Reviews (2011a, b).

[13] For further details, see UNDP (2010), UNCTAD (2010).

Table 1 El Salvador in the Central American context, 2009

	Costa Rica	El Salvador	Guatemala	Honduras	Nicaragua	Panama
GDP (million dollars)	29,240	21,101	37,322	14,318	6,140	24,711
GDP per capita (purchasing power parity, dollars)	11,106	6,629	4,720	3,842	2,641	13,057
Total Population	4,578,945	6,163,050	14,026,947	7,465,998	5,742,800	3,453,898
Surface area (km^2)	51,060	20,720	107,160	111,890	119,990	74,340
Human Development Index 2010 (ranking)	62	90	116	106	115	54

Source World Development Indicators, World Bank; UNDP (2010)



Graph 1 GDP evolution and growth rate, 1990–2009. *Source* Author, based on data from World Development Indicators

remittances[14] has financed high consumption levels, not satisfied by internal production, motivating the import of goods and services, creating significant imbalance regarding the scale of goods and services. These family remittances have not been used for investment[15] and have even been accompanied by a decrease in the national savings rate. The extension of private credit has served to finance high consumption levels. The high volume of remittances puts the country's industrialization

[14] In 2009, family remittances, in spite of being affected by the economic crisis, reached 3,465 million dollars and represented 16.4 % of the GDP.

[15] An IMF study shows that 80 % of remittances are destined to consumption and only 15 % are destined to health and education expenses and 5 % to investment and savings (Cáceres and Saca 2006).

Table 2 El Salvador: selection of economic indicators, 2004–2009

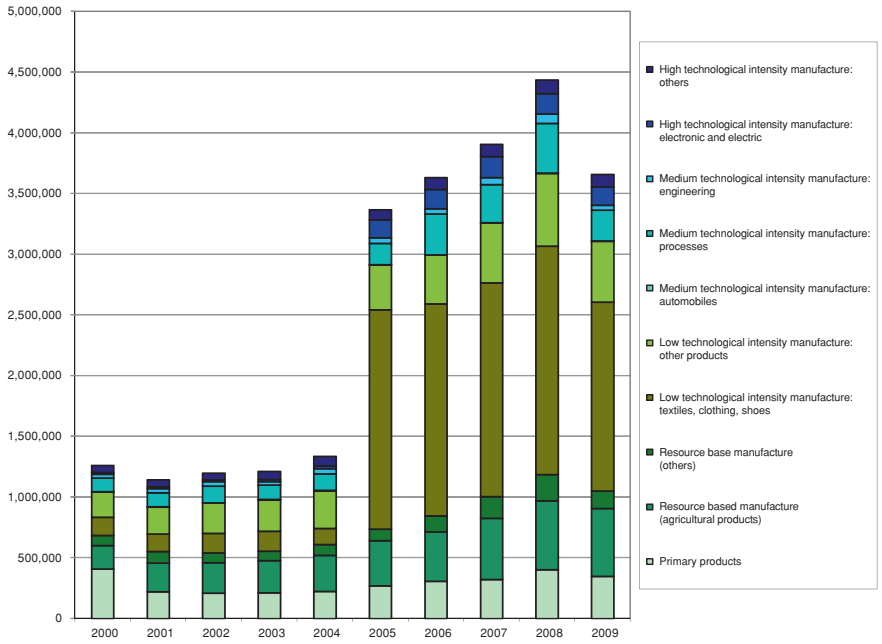
	2004	2005	2006	2007	2008	2009
Global demand in million dollars (constant prices of 1990)	13,194	13,636	14,479	15,339	15,849	14,014
National consumption expenditure	8,380	8,783	9,201	9,927	10,318	9,408
Homes	7,737	8,126	8,530	9,269	9,622	8,682
Public administrations	643	657	671	658	695	726
Gross capital formation	1,540	1,607	1,857	1,754	1,671	1,380
Gross fixed capital formation	1,485	1,513	1,703	1,754	1,671	1,380
Private	1,337	1,317	1,505	1,570	1,466	1,167
Public	148	197	198	184	206	213
Change in stocks	55	94	154	0	0	0
Goods and services exports	3,274	3,246	3,422	3,658	3,861	3,226
Global offer in million dollars (constant prices of 1990)	13,194	13,636	14,479	15,339	15,849	14,014
Goods and services imports	5,026	5,196	5,684	6,163	6,450	4,948
GDP	8,168	8,440	8,795	9,176	9,399	9,067
GDP per capita (dollars at current prices)	2,621	2,846	3,087	3,341	3,609	3,430
GDP per capita (constant dollars, 1990)	1,355	1,395	1,448	1,505	1,535	1,474
Growth rate of real GDP per capita	1.5	3.0	3.8	3.9	2.0	−4.0
Inflation rate	5.4	4.3	4.9	4.9	5.5	−0.2
Family remittances as GDP percentage	16.1	17.5	18.5	18.1	17.1	16.4
Growth rate of real GDP	1.9	3.3	4.2	4.3	2.4	−3.5
Consumption	2.8	4.9	5.0	8.3	4.3	−9.8
Government	0.1	0.2	0.2	−0.2	0.4	0.3
Private	2.7	4.8	4.8	8.4	3.8	−10.2
Investment	−0.8	0.8	3.0	−1.2	−0.9	−3.1
Exports	1.4	−0.3	2.1	2.7	2.2	−6.9
Imports (−)	1.6	2.1	5.8	5.5	3.1	−16.3
GDP (million dollars at current prices)	15,798	17,214	18,749	20,377	22,107	21,101
Gross national savings	1,918	2,117	2,403	2,025	1,614	2,394
Private	1,700	1,872	2,063	1,570	1,220	2,662
Public	218	245	340	455	393	−268
Foreign savings	642	610	783	1,221	1,682	374

Source Author, based on data from the UNDP (2010), ECLAC

at risk by increasing the price of non-tradable products and causing a loss in competitiveness for the traditional export sector.

On the other hand, El Salvador invests less in gross fixed capital formation than other countries in Central America, both in relative GDP and in absolute terms.[16] Also, the effort to provide necessary savings and investment for the development of production skills has declined in recent years (Table 2). Finally, the low tax revenue rates and high levels of debt limit the availability of public resources. It is estimated that in 2010, total public debt absorbed 50 % of GDP and tax revenue capacity was limited to 13.2 % of GDP (ECLAC 2011).

[16] With the exception of Nicaragua, which invests less in absolute terms.



Graph 2 Evolution of export goods based on their technological intensity (according to the Lall products classification) (millions of dollars), El Salvador, 2000–2009. *Source* Author, based on data from the UNSD Comtrade (February 2011)

Trade and Trade Policy

El Salvador has promoted an open trade policy based on developing the assembly industry for re-export. Consequently, the assembly industry has accounted for an important volume of exports since 2005, and next to family remittances, it represents the main source of currency in El Salvador. The remaining product exporting sector is very diverse. Among the most exported products are traditional products such as coffee and sugar and other non-traditional items such as generic drugs. High and medium technological intensity manufacture has little predominance among exports. The most important exports in regard to services are in the transportation and travel sector although transportation presents a negative balance (see Graph 2; Tables 3, 4).

Imports once presented dynamic behavior, but this was interrupted by the 2009 crisis and is only now beginning to recover (Graph 3). The proportions represented by consumer goods, intermediate goods, and capital goods have remained more or less stable, subject to price variations (e.g., the oil price). However, a growing trend is apparent regarding the proportion of consumer goods related to overall imports and a reduction of imports related to transportation and communication services, as well as imports for the assembly industry, as a result of the crisis (Graph 3).

El Salvador has a strong commercial dependence on the United States. 48.3 % of exports are destined to the United States. The other principal commercial partners are

Table 3 Imports and exports of El Salvador, in millions of dollars, 2009

	Exports	(%)	Imports	(%)	Balance
Goods (FOB)	3,860.9	100.0	6,706.1	100.0	−2,845.2
General w	2,287.3	59.24	5,780.6	86.20	−3,493.3
Coffee	230.3	0.06			
Sugar	88.4	0.02			
Prepared medication—therapeutic/prophylactic use	97.8	0.03			
Cut-out toilet paper for domestic use	96.9	0.03			
Goods for transformation (Maquila)	1,487.4	38.52	839.0	12.51	648.3
Services	835.2	100.00	1,260.3	100.00	−425.1
Transportation	271.5	32.51	700.4	55.57	−428.9
Travel	319.4	38.24	186.8	14.82	132.6
Communications	141.0	16.88	32.2	2.55	108.8
Construction	24.9	2.98	10.3	0.82	14.6
Insurance	30.1	3.60	174.6	13.85	−144.5
Financial	1.0	0.12	7.8	0.62	−6.8
Information services	0.1	0.01	4.3	0.34	−4.2
Royalties	0.4	0.05	26.0	2.06	−25.6
Personal, cultural, and recreational	0.0	0.00	0.5	0.04	−0.5
Government services	29.1	3.48	29.0	2.30	0.2
Other business services	17.6	2.11	88.3	7.01	−70.7

Source Central Reserve Bank of El Salvador and ECLAC (2011)

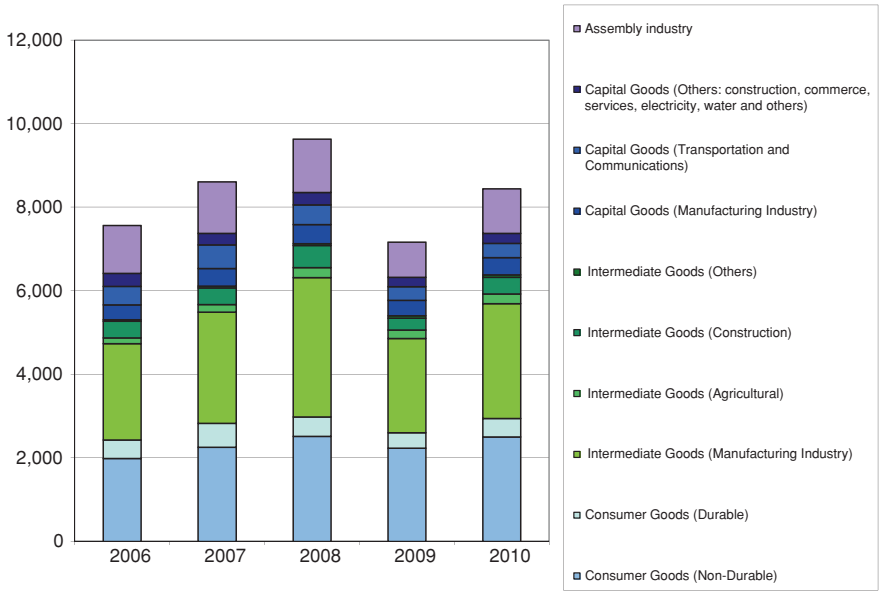
Table 4 Balance of payments of El Salvador, million dollars, 2004–2009

	2004	2005	2006	2007[a]	2008[a]	2009[a]
Current account balance	−642	−610	−783	−1,221	−1,682	−374
Goods and services balance	−2,739	−3,066	−3,724	−4,395	−4,978	−3,270
Exports	4,290	4,392	4,774	5,169	5,652	4,696
Imports	−7,029	−7,459	−8,498	−9,564	−10,629	−7,966
Income	−458	−579	−531	−576	−536	−664
Transfers	2,555	3,035	3,472	3,750	3,832	3,561
Worker remittances	2,548	3,017	3,471	3,695	3,788	3,465
Balance in finance and capital accounts	276	929	1,094	400	1,380	500
Reserves	53	59	−72	−280	−334	−429

[a]Preliminary figures
Source Central Bank of El Salvador

countries in Central America [Guatemala (13.8 %), Honduras (12.8 %), Nicaragua (5.4 %), Costa Rica (3.6 %), and Panama (2.3 %)].[17] In this context, it is apparent that in July 2010, the Ministry of Economics launched the Integral Export Promotion Strategy 2010–2014, aiming to internationalize companies and increase competitiveness in El Salvador (see Sect. 3.2.2).

[17] Based on data from the Central Reserve Bank of El Salvador.



Graph 3 Evolution of imports (million dollars), El Salvador 2006–2010. *Source* Author, based on data from the Central Reserve Bank of El Salvador

Foreign Direct Investment[18]

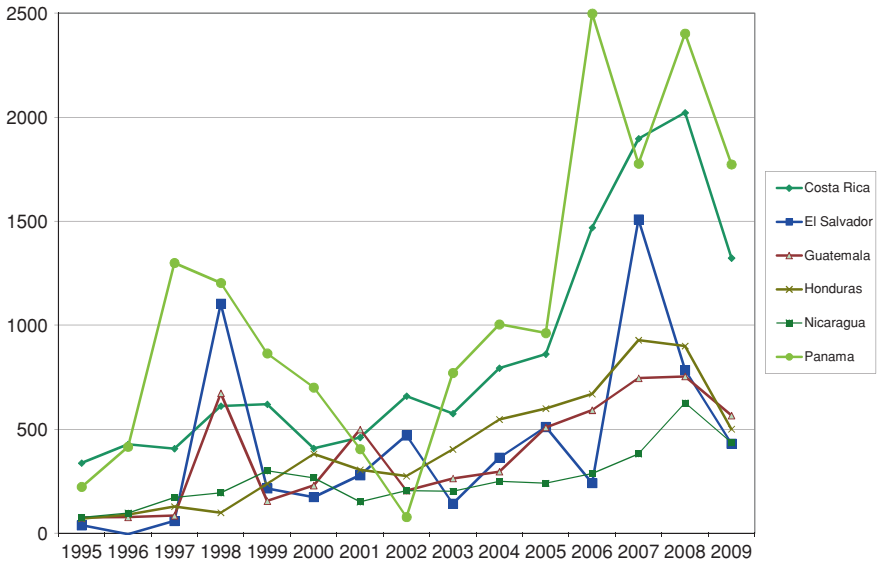
Since 1995, El Salvador has attracted a total of 6.3 billion dollars with an average of 421 million dollars a year. In 2009, the total stock of foreign direct investment was 7,132 million dollars (Graph 4). El Salvador is situated far behind Panama and Costa Rica in terms of its capacity to attract foreign investment, both in absolute terms and per capita. Since 1995, the entry of foreign direct investment per capita in El Salvador has represented an average of 70 dollars, while Panama and Costa Rica had an average of 346 and 203 dollars, respectively.

2.1.2 Structural Conditions

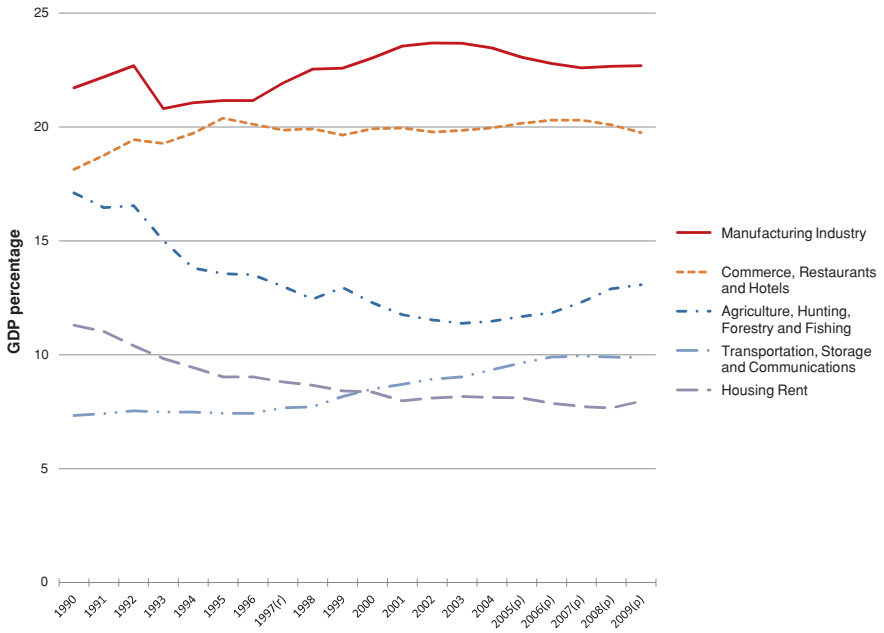
Sectorial Structure

El Salvador has a diversified economy. In the manufacturing sector (which contributed 24.1 % of the GDP in 2010), the assembly industry (11 % of the manufacturing sector), the chemical industry (9.4 %), and milling and bakery products (8.8 %) are predominant. The commercial sector, which includes trade, restaurants, and hotels, is second in importance, representing 21 % of the GDP in 2010 (Graphs 5, 6). The

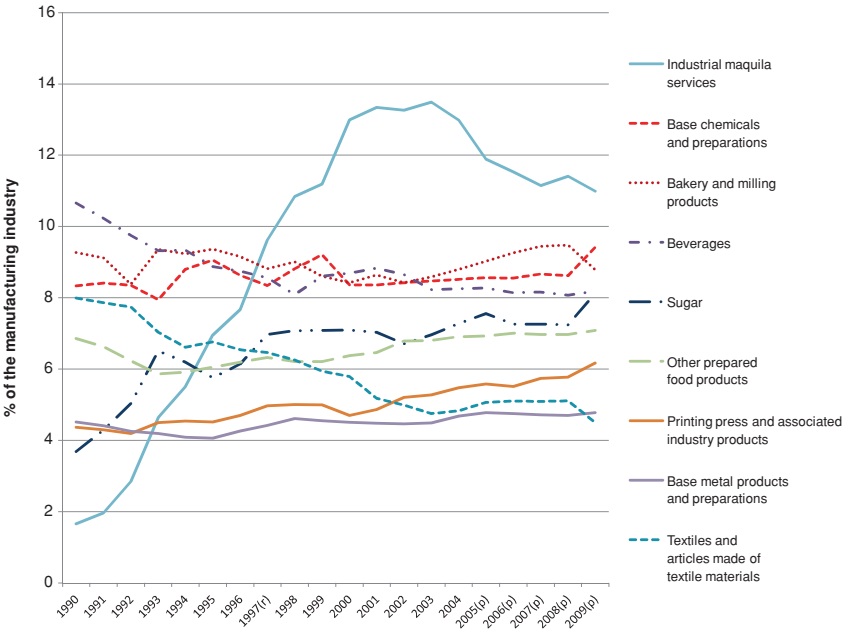
[18] For further details, see UNCTAD (2010).



Graph 4 Entry of foreign direct investment, Central American countries, millions of dollars, 1995–2009. *Source* UNCTAD, FDI database



Graph 5 Contribution to the gross domestic product of the main branches of economic activity. *Source* Author, based on data from the Central Reserve Bank of El Salvador



Graph 6 The manufacturing industry of El Salvador, 1990–2009. *Source* Author, based on data from the Central Reserve Bank of El Salvador

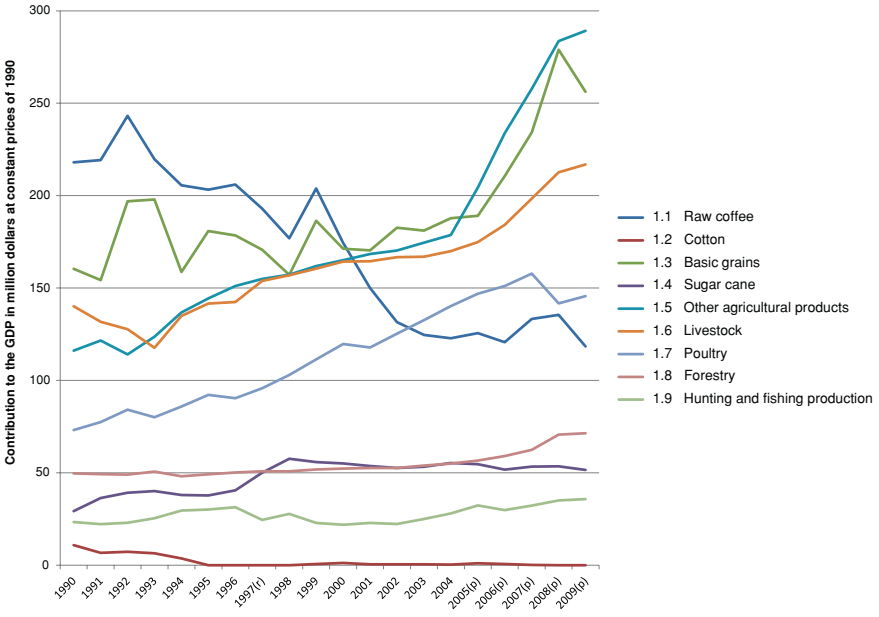
infrastructure sector (where transport, storage, and communications stand out, but which also includes construction, electricity, gas, and water) has performed well and currently represents 14.7 % of GDP. Within the financial sector, which represents 12.3 % of GDP, it is worth mentioning the performance of banking and insurance establishments. Government expenditure has greatly deteriorated, and in 2009, it was only 5.2 % of GDP.

The agricultural sector decreased as a proportion of the national economy during the 1990–2003 period with a slight increase since then, contributing 14 % of GDP in 2009. This sector has undergone significant changes and now mainly focuses on other types of agricultural production, basic grains, and livestock. Raw coffee, the most important agricultural product in the 1990 s, is no longer as important as it once was (Graph 7).

2.1.3 Operating Principles for the Execution System

Business Structure

The industrial sector of El Salvador is characterized by a large component of microenterprises, employing nearly 36 % of personnel employed in the country (DIGESTYC 2005). The commercial sector comprises a large number of establishments, but



Graph 7 Principal activities of the agricultural sector. *Source* Author, based on data from the Central Reserve Bank of El Salvador

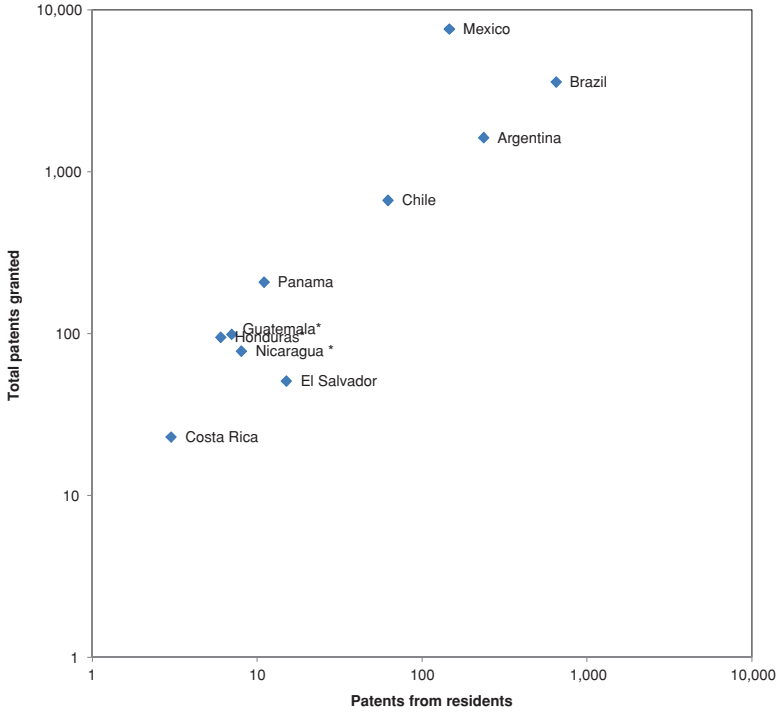
Table 5 Business structure by economic activity, 2005 Census

	Establishments	%	Individuals	%
Services	32,180	18.37	258,137	36.90
Industry	22,788	13.01	195,650	27.97
Trade	115,540	65.96	183,126	26.18
Transport and communications	4,065	2.32	30,819	4.41
Construction	447	0.26	16,838	2.41
Agro-industry	79	0.05	8,860	1.27
Water and electricity	71	0.04	5,937	0.85
Mines and quarries	8	0.00	214	0.03
Total	175,178	100.00	699,581	100.00

Source Digestyc (2005)

contributes less to the job market in comparison. Trade comprises 66 % of establishments, but only employs 26 % of workers (Table 5).

As in the rest of Latin America, besides the external productivity gap, El Salvador also suffers from internal gaps, in the form of marked differences in productivity between different sectors, as well as within these and between companies in the country (micro, small, medium, and large, or between national and transnational countries), far exceeding those experienced in industrialized countries (ECLAC 2010).



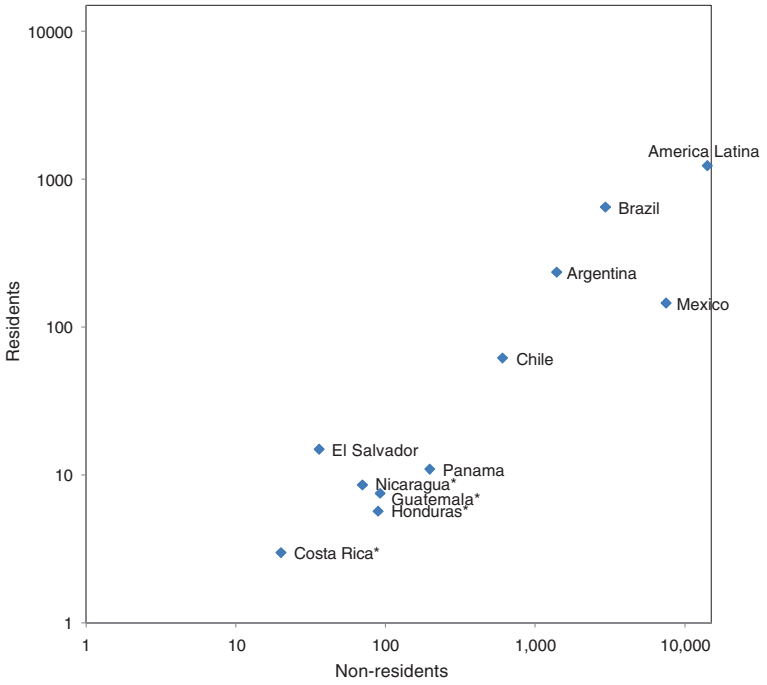
Graph 8 Ratio of annual average of patents granted to residents to the total patents granted to Central American countries and some Latin American economies, 2000–2008 (log scale). *Source* Author, based on data from the RICYT. *Note* Asterisks indicate that the series of data are incomplete

Regarding innovation skills—if we take patent intensity as an indicator,[19] these are relatively low, with a lower average of 8 patents per year in the Espacenet records,[20] compared to 15 in RICYT, [21] where despite a growing trend, there was an apparent decrease between 2005 and 2009. Using the RICYT data as a basis for comparison, this patent intensity pattern is very similar for the entire Central American region, where El Salvador is well positioned, indicating a higher annual average of patents granted to residents and a better ratio when compared to the total (Graph 8) as well as compared to non-residential patents (Graph 9) and

[19] This might not be the best indicator, but it offers an adequate approximation regarding the lack of more precise information.

[20] Considering all registered patents, where one of the inventors *resides* in El Salvador (not necessarily implying that they have Salvadoran nationality).

[21] Corresponding to the aggregate patterns for patenting in Central America and some Latin American economies, from 2000 to 2008. The RICYT databases are prepared with information provided by the organisms in charge of the science and technology statistics for each country. A certain degree of reserve must be maintained in these comparisons, because this information is often incomplete.



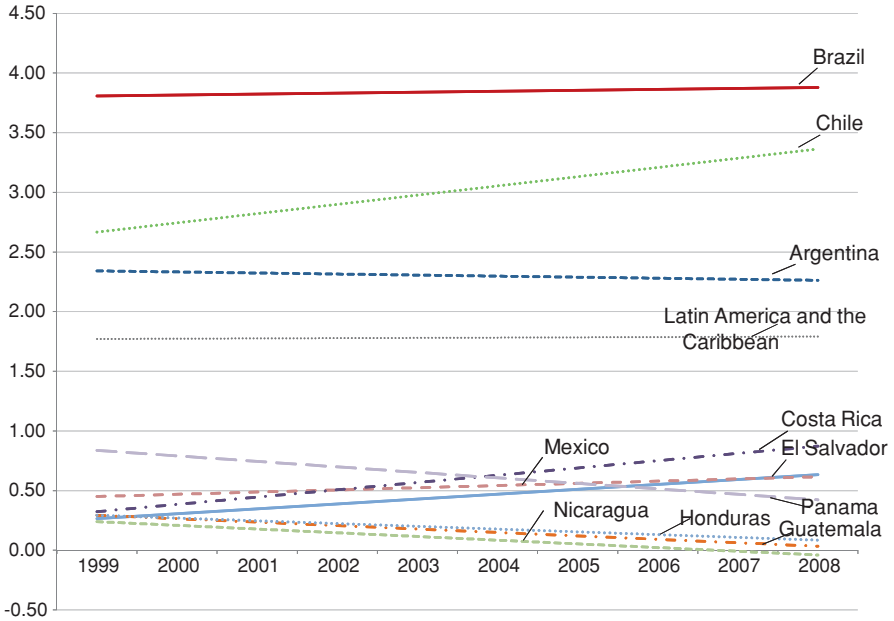
Graph 9 Ratio of annual average of patents granted to non-residents to patents granted to residents of Central American countries and some Latin American economies, 2000–2008 (log scale). *Source* Author, based on data from the RICYT. *Note* Asterisks indicate that series of data are incomplete

showing the invention rate (patents requested by residents with respect to the population) is only below Costa Rica (Graph 10).

Graph 8 presents a representation of a similar indicator to that known as the self-sufficiency rate in RICYT (patent requests from residents divided by total requested patents), where El Salvador's position would have the greatest advantage among those countries included. Similarly, Graph 9 represents a comparable indicator to the one termed rate of dependency (patent requests from non-residents divided by requests from residents) by RICYT and correspondingly El Salvador is the highest among countries in Central America.

Although this comparative information is encouraging, we must not forget that the patenting intensity of a country is multifactorial and reflects, among other aspects, the economic dimension, industrial specialization patterns, the dimension of its internal market, its international trade, exports, etc. When considering all of these factors, it is apparent that although indicators relating to El Salvador are balanced and positive, they also reveal a small economy with a reduced internal market and little capacity for high-technology product export.

Likewise, fieldwork carried out on different companies reveals that occasionally, these are involved in research and development activities and even incorporate

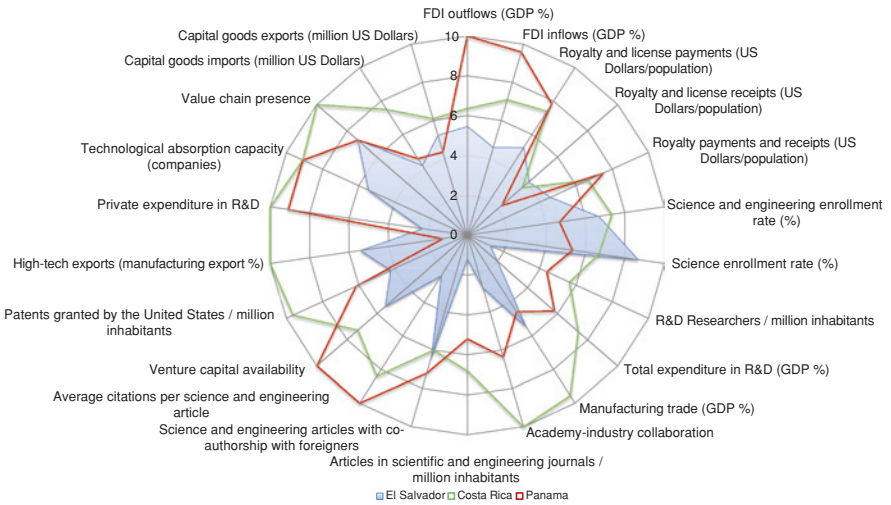


Graph 10 Trends of invention coefficients of Central American countries and some Latin American economies, 1999–2008. *Source* Author, based on data from the RICYT. *Note* The invention coefficient corresponds to the number of patents requested by residents per 100,000 inhabitants

innovations in their products and processes, but do not consider these as such nor do they include them in their account statements. This implies that the R&D effort and its incorporation into innovation is greater than that revealed by conventional indicators. However, by using other analysis criteria, the country's results are still low regarding their main competitors in Central America (see Graph 11).

Business Competitiveness

Based on the global competitiveness index (WEF 2012), El Salvador continues to indicate a decline in competitiveness. At present, the country is in position 91, far behind Panama (49) and Costa Rica (61) and somewhat behind Guatemala (84). Certain strong indicators reported by the World Economic Forum highlight the efficacy of the goods market and the development of infrastructure (roads, aviation, and mobile communication), as well as certain macroeconomic conditions (particularly inflation rate control), the quality of local suppliers, and labor flexibility. However, the country is limited by its low capacity for innovation, weakness of public institutions, and poor quality of the educational system. For investors and executives, criminality, instability of policies, and limited access to financial resources are the main obstacles to carrying out business in the country (WEF 2012).



Graph 11 Innovation indicators according to the knowledge evaluation methodology of the World Bank (KAM). *Source* Author, based on data from the World Bank (www.worldbank.org/kam)

Infrastructure

El Salvador's infrastructure has improved significantly in the last two decades; it has a good road network and aviation infrastructure. The El Salvador road network includes 6,600 km, half of which are paved. The port infrastructure has been vastly improved with the construction of a second port in La Unión, intended to become a loading hub for Central America. The port's construction was finished in 2009; however, its commissioning has been considerably delayed due to difficulties in approving its management model.

El Salvador is a net importer of electrical power and the greatest producer of geothermal power in Central America. The electrical infrastructure covers 83 % of its territory (97 % in urban regions and 72 % in rural regions). The country has an installed capacity of 1.490 megawatts (MW) and a net generation capacity of 5,504 gigawatts per hour (GWh).[22] El Salvador is part of the SIEPAC electrical infrastructure project, the first electrical transmission system which aims to reduce the cost of electricity by forming a regional electricity market.

The telecommunications infrastructure has also developed significantly in the last decade, especially mobile telephone services, where we find 113 subscriptions per 100 inhabitants. Although the number of fixed telephone lines has tripled in the last decade, at present there are only 17.5 fixed lines per 100 inhabitants, representing an average per inhabitant still far below that of Costa Rica.

[22] ECLAC (2010).

Education

Education is a key element in the development of skills and abilities required for a competent and productive workforce. This fundamental element is one of the El Salvador's weaknesses. El Salvador has invested an average of 3 % of GDP in education (1999–2011), far from the investment averages for Costa Rica (nearly 5 %) and Panama (above 4 %). The approved budget for 2011 reached 704.69 million dollars.[23]

There has been great progress in schools in recent years, but the long-standing low investment levels in education have limited educational achievements. The set of educational quality and coverage indicators (Table 6) indicates that the country is in a better position than Guatemala, Honduras, and Nicaragua, but behind Costa Rica and Panama. The most significant weaknesses concern student permanence and school system coverage, especially in secondary school and kindergarten, as well as in student achievements.

Regarding the quality of higher education, it is difficult to generalize, as evidently institutions vary—public, private, and by study degree (MINED 2009).[24] Nevertheless, national statistics are useful for obtaining an overall impression of the country; according to these, the performance of El Salvador is uneven and may be rated as average. Likewise, indicators from external sources still show results as average and in some cases low, with significant need for improvement (see Graph 12).[25]

A number of interviews with company members were used to complete information, indicating a degree of dissatisfaction in the production sector regarding the quality and content of various scientific and technological careers, rating them as out of date and inadequate for the formation of professionals, who could be incorporated into the industry without the need for additional training on the part of the company.

Research and Development (R&D)

In El Salvador, there is a prevailing production specialization modality based on the assignment of production resources according to static competitive advantages, as these generate dynamic competitive advantages demanding the development and diffusion of technical innovations and organizations supported by access to networks formed by advanced liaisons between companies and knowledge sources. Generally, a dual structure has been developed, where productivity improves within a relatively small economic context without any relation to the rest of the production system. Simultaneously, the scarce diffusion of research and development (R&D) activities and the substitution of local sources of knowledge

[23] This budget does not include two priority programs established in the 2010–2014 Quinquennial Development Plan.

[24] Similarly, fieldwork revealed positive and negative opinions regarding some universities, technological institutes, and training organisms.

[25] WEF (2011).

Table 6 Education coverage and quality indicators in Central America, 2008

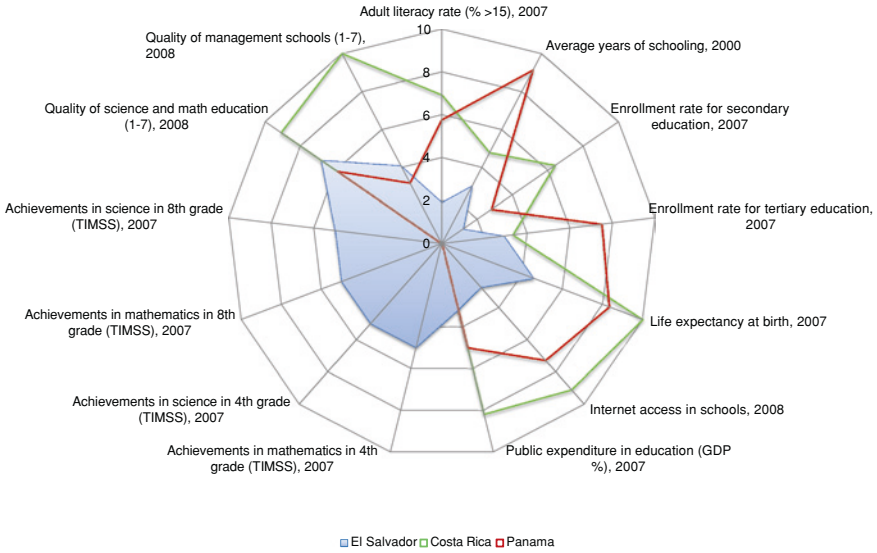
	Costa Rica	El Salvador	Guatemala	Honduras	Nicaragua	Panama
Illiterate population aged 15 years or older (% of the population aged 15 years or older), 2010	3.2	16.6	25.2	19.4	30.3	6.0
Public expenditure on education (% of GDP), 2008	5.1	3.6[d]	3.2	–	3.1[a]	3.8
Net enrollment rate, primary school (%), 2008	–	94.2[d]	95.1	–	91.8	98.3
Net enrollment rate, secondary school (%), 2008	–	56.4[d]	39.9	–	45.2	65.6
Gross enrollment rate, tertiary education (%), 2008	–	24.6	17.7[c]	17.1[b]	18[a]	45.1
Average number of students per teacher, primary school, 2008	18[d]	31[d]	29	33	29	24
Average number of students per teacher, secondary school, 2008	16[d]	24[d]	17	–	29	15
Persistence up to 5th grade, 2007–2008	96	80	71	78	51	87
Ranking for education for overall development index, 2007	–	94	98	87	101	66

Notes
[a]Data year 2003
[b]Data year 2004
[c]Data year 2007
[d]Data year 2009
Source Author, based on the ECLAC (2011) Statistical Yearbook

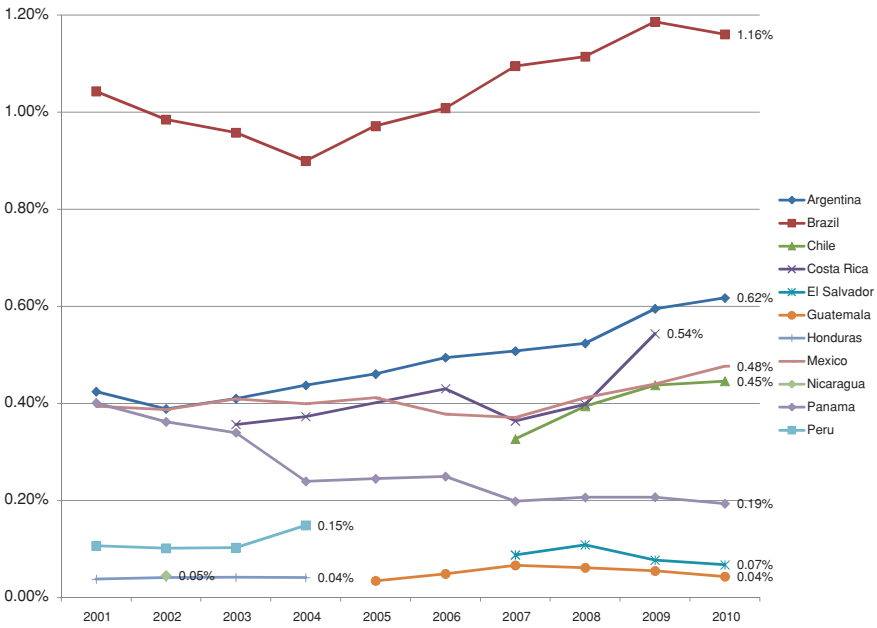
by external ones have acted as additional hurdles to the efforts made to reduce the production and technology gap.[26]

Investment in R&D in El Salvador is limited both in absolute terms and in relation to GDP (Graph 13). It is estimated that the country invested 0.11 % of its GDP in 2008. Although El Salvador is at the head of the group of four Central American countries (Guatemala, Honduras, Nicaragua, and El Salvador), the country is lagging behind Costa Rica and Panama and far from the levels of investment

[26] See Pacto para el Crecimiento: El Salvador, Análisis de Restricciones. Equipo Técnico Conjunto USG-GOES 7/19/2011, at http://photos.state.gov/libraries/elsavador/92891/PFG/ES%20Constraints_Analysis_Espa__ol.pdf retrieved in November 2012.



Graph 12 Education indicators according to the knowledge evaluation methodology for the World Bank (KAM). *Source* Author, based on data from the World Bank (www.worldbank.org/kam)



Graph 13 Comparative evaluation of R&D expenditure (as a percentage of GDP), El Salvador and selected Latin American countries, 2000–2008. *Source* RICYT. *Notes* El Salvador: expenditure on the part of higher education and government sectors

on R&D in the Latin American countries that are more advanced in the field (Brazil, Mexico, Argentina, and Chile).

R&D expenditure executed by higher education institutions is primarily financed by the government and the institutions themselves. The latest data reflect a significant reduction in R&D financing by higher education institutions. In 2009, the public sector financed 64 % of this expenditure, while the higher education institutions themselves lowered their contribution considerably compared to the previous year and only financed 23 % of total R&D expenditure.

Science and Technology Activities

Among science and technology activities, teaching and formation is the most important sector, with an increasing tendency toward participation on the part of the academic sector. On the other hand, the low level and proportion (2 %) in terms of expenditure in science and technology services indicate a poor liaison between the country's academic sector and the production sector.

Expenditure on activities related to science and technology is also destined in a high percentage to social sciences and humanities (44 % of the expenditure in 2009). 20 % of expenditure is destined to engineering and technology, followed by exact and natural sciences (17 %), medical sciences (15 %), and agricultural sciences (4 %). Similarly, concerning the socioeconomic objective, spending on science and technology activities is highly oriented toward social structures and relationships. For example, three times more is spent on this objective than on the protection or improvement of human health.

Scientific Production

In a bibliometric study carried out in the STI policy analysis, UNCTAD/ECLAC (2011a), 420 publications were identified in indexed journals, where authors resident in El Salvador participated,[27] comprising an average of four articles annually in recent years (the lowest number in Central America). Research subjects with the greatest number of publications consist of public, environmental, and occupational health, as well as plant sciences. Areas having the greatest impact include immunology, respiratory systems, meteorology, atmospheric sciences, and science, together with food technology. If we only consider articles where the first author resides in El Salvador, the areas of the greatest impact are oncology, orthopedics, health policy and services, pediatrics, andrology, nutrition, and opthalmology. The University of El Salvador stands out from all other research organisms for its production volume. In terms of the impact of publications, research from Salvadoran organisms registers a low impact, with the exception of Hospital Rosales.

[27] The search period dates from 1941, although there are only three publications prior to 1972, the year in which they increase in number and systematic approach strengthens.

3 Policy Rationales

3.1 Identification of Conditions or "Faults" Justifying Intervention

Innovation is a vector and not a sector, and therefore, the challenge for public policy is to incorporate and articulate regulatory aspects, along with those of cohesion and prospective vision (policies and strategies) as well as including management, control, and regulation (policy instruments, evaluation, and adjustments) and, at the same time, management with execution (instrument management, follow-up, and control).

There is no optimal science, technology, and innovation policy. The goals and instruments of STI policies must respond to the context and specific needs of each country, as well as to financial capacities and history in terms of STI policies and institutions, while conforming to current capacities. Within a broader context, policies have transformed their intervention logic, from policies of selective supply in the 1970s, which led to the promotion of a technological base to support an industrialization model by substitution of exports, up to policies for promoting demand from the business sector in the 1990s. At present, the policy mix is more diverse, as it adopts a systemic perspective and points toward interaction between the stimuli of supply and demand (ECLAC 2010).

Successful experiences emphasize the importance of the synchronization of STI policies and national social, economic, and production development policies, and the need to minimize flaws of coordination and superposition of different policies, as well as ensuring temporary cohesion. It is necessary to begin to understand that the success of policies is not determined *ex ante*, but rather requires a continual learning process based on trial and error, as well as a firm decision-making structure when designing institutions and science, technology, and innovation policies (ECLAC 2009; UNCTAD 2007).

Given the governing characteristics and conditions in El Salvador, it is estimated that there is a need for a set of coordinated and coherent policies which will both correct the various market flaws and stimulate the development of assimilation skills, facilitating the participation of the national production system in the global economy. Similarly, horizontal policies are required, which respond to market flaws and information asymmetries, promote the formation of human capital, facilitate general diffusion and assimilation of knowledge, and allow companies to improve their position within the limits of their possibilities for innovation.

Vertical and selective policies are also required, supporting specific sectors and technologies, promoting cooperation and articulation between universities and research institutions and companies, while permitting the creation of useful knowledge and business competitiveness at a national level. Facilitating policies are also needed, in order to remedy systemic flaws and broaden the possibilities of innovation for all companies. Policies that promote the development of the knowledge infrastructure and establish an adequate institutionalism will ensure that different actors of the innovation system interact, learn, and have a clear reference framework.

A general STI policy framework should consider (1) cohesion and coherence between plans; (2) cohesion and coherence between policies; and (3) cohesion and coherence between instruments.[28] The most common practice applies a mixed approach, building matrixes which combine the range of types and objectives in order to characterize what some authors call the policy mix of a particular country.[29] This general framework describes an ideal type of science, technology, and innovation policy, and the challenge is to evolve authentic and effective reforms of institutions inherited from the past, redefining a new institutionalism which maintains the systemic dimension of these policies and articulates top-down and bottom-up elements (ECLAC 2010).

3.2 Evolution of the Institutional Framework and Its Role in Science, Technology, and Innovation (STI) Policy

3.2.1 Governmental Organizational Framework (Direction and Cohesion)

Toward the end of 2012,[30] no single organism in El Salvador was responsible for the integral government of the STI policy system; instead, it was fragmented into several ministries and organisms whose functions notably included certain STI activities. Among these, the following are the most important: the Technical Secretariat of the Presidency (STP) that directed the 2010–2014 preparation of the Quinquennial Development Plan; the Ministry of Agriculture and Farming (MAG), directly responsible for the National Center of Agricultural and Forestry Technology (CENTA)[31]; the Ministry of the Economy (MINEC) which by way of their Vice-Ministries of Economy and of Industry and Trade design and implement innovation policies; and the Ministry of Education (MINED) which through the Vice-Ministry of Science and Technology promotes activities that benefit scientific and technological development.

However, in terms of legal and regulatory aspects, the role of higher authority in science and technology is fulfilled by the National Council for Science and Technology (CONACYT).[32] This is precisely one of the organisms, undergoing a transformation process due to government restructuring (see note 34), which until

[28] See the UNCTAD/ECLAC (2011a) report, p. 48, for more detailed information on the main STI policy instruments.

[29] See UNCTAD/ECLAC (2011a), p. 58.

[30] It is important to mention that since 2009, the new administration began an organizational restructuring which had a significant impact on the governance of the STI policy system.

[31] The only research center in the country apart from higher education institutions.

[32] National Science and Technology Council Law, Legal Decree Nº 287, Official Gazette, August 10, 1992 [Ley del Consejo Nacional de Ciencia y Tecnología, Decreto Legislativo Nº 287, Diario Oficial, 10 de agosto de 1992].

mid-2010 had been an autonomous institution dependent on the MINEC. Currently, functions that were related to the promotion of science, technology, and innovation have been transferred *de facto* to the Vice-Ministry of Science and Technology, although its scope of functions cannot yet be established as the Law on Scientific and Technological Development (LDCyT) is undergoing an approval process. Likewise, the quality functions it carried out will be tended to by the Salvadoran System for Quality (SSC).[33]

3.2.2 National Policy Framework (Foresight)

National Science, Technology and Innovation Policy, 2006–2030—One of the documents outlining relatively recent national STI policies, which has served greatly as a basis for present policies, is the one prepared by the National Science and Technology Council in 2006, updating the prior policy, which dated back to 1997 (CONACYT 2006). This was structured around a global framework, which presented a general view of a country focused on social well-being and how science and technology contribute to this. Additionally, 13 prospective proposals were included in order to integrate and facilitate the general outlook, with a time horizon up to 2030.

The document included 21 conditions or factors necessary for achieving the country's targets, 13 areas of knowledge for STI development, ten objectives, and 15 general lines of political action, as well as seven strategic components including a description, lines of action, respective institutional framework, and recommended "instruments"[34] for implementing these 2010–2014.

Quinquennial Development Plan (PQD)—This has a much broader scope,[35] as it comprises a comprehensive development plan for El Salvador and is the most important general policy document used by the government in terms of functions, including a series of planning proposals aimed at orienting the formulation of specific policies, among which we can find those related to science, technology, and innovation (Government of El Salvador 2010).

The plan is structured around two strategic objectives: (1) the establishment of a new integral growth and development model and (2) strengthening and consolidating democracy. Apparently, guidelines related to STI activities can be identified in the first objective, among which we can highlight quinquennial goals that are either directly or indirectly associated with science, technology, and innovation:

- Achieving a real average growth rate of the gross domestic product of 4.0 % at the end of the period;
- Generating at least 250,000 new jobs by executing public investment projects;
- Increasing goods and services exports by at least 20 % at the end of the quinquennial; and

[33] See Sect. 3.2.4.

[34] Not necessarily STI *policy instruments*.

[35] Also with a more realistic time horizon, until 2024, that will receive two future reviews.

- Strategic policies, which are formed by applying the following: (1) social strategies, including education (which includes scientific and technological research); (2) the financial system for the promotion of development, including the restructuring of development banking[36]; (3) a strategy for production development for coordinating government resources and for creating financing modalities that promote innovation and strengthen business management and productive bets differentiated by vocations and potentiality of territories; and (4) macroeconomic and sectorial policies: tax, export promotion, energy, the environment, agriculture, and tourism.

National Scientific and Technological Development Plan—The National Scientific and Technological Development Plan has the following reference: the aforementioned CONACYT work for the period 2009–2030; the 2010–2014 Quinquennial Development Plan; and the National Research Agenda prepared by MINED, by way of the VM° of Science and Technology.[37] The plan has the general objective of establishing scientific and technological criteria oriented toward the economic and social development of El Salvador. It has nine specific objectives that tend to strengthen STI activities, as well as their application in the quest for economic, social, and developmental benefits (MINED 2010b).

To obtain these results, we mention the need to plan development and articulate the scientific and technological development system which deals with social demands and produces results that strengthen the common good. Likewise, the plan's scope of action makes reference to the National Research Agenda, which is binding with the PQD by way of a synthesis matrix, where the strengths of research have been identified in approximately 29 areas and 156 strategic lines.[38]

The management and strategic direction of the plan is the responsibility of the MINED, through the VM° of Science and Technology, which will be maintained by its own structure. Its execution implied the participation of a group of centers, institutions, entities, and organs related to the public and private sector, and to research and higher education institutions, whose activities fall into the category of STI or dedicate a portion of their budget and human resources to these activities. In turn, the Research Agenda has defined the content of the plan to include 10 programs and 32 projects.

Integral export promotion strategy—In mid-2010, the MINEC launched an export promotion strategy (MINEC 2010): a document aimed at strengthening activities that make foreign trade more dynamic. It centers on five axes directed toward achieving particular goals[39]: (1) the need to invest in processes that promote exports; (2) the incorporation of innovation in these processes; (3) linking activities that

[36] See Sect. 4.4.1.

[37] Prepared with support from the scientific community of El Salvador.

[38] The priorities in research, development, and innovation were identified by raising information regarding the activities carried out and the potential of the research centers or units of El Salvador.

[39] By the year 2024, the following is generally proposed: tripling the number of export companies, increasing the number of destinations by 25 %, tripling income from exports, and increasing the number of exported products by 25 %.

involve foreign trade and the creation of quality jobs; (4) strengthening of productive inclusion (production chains, business alliances, collaboration, etc.); and (5) the exploitation of free trade agreements. Likewise, it has been claimed that transversal strategy axes are formed by the incorporation of innovation and quality systems. The strategy presents five objectives which include 16 strategic areas and various lines of action, from which 21 specific programs and instruments are derived.

Industrial Policy—Between 2010 and 2012, a multidisciplinary and multisectorial work team headed by the STP, the MINEC, the MAG, the Central Reserve Bank (BCR), and the Salvadoran Industrial Association (ASI) worked on the formulation of an industrial policy with a horizon from 2011 to 2024.[40] The intention here is to achieve a diversified, modern, and competitive industrial and agro-industrial sector, capable of articulating with the other sectors of the economy and significantly incorporating technological innovation in production processes.

The strategic axes of industrial policy include the following:

1. An increase in productivity.
2. A decrease in production costs.
3. The exploitation of international trade opportunities.
4. Financing.
5. The incursion into new industrial branches by undergoing a transformation from manufacture-based industry to knowledge-based industry.
6. Support for small and medium businesses.
7. Institutional and legal framework.

Priority sectors identified by their economic positions include food and beverages, chemical pharmaceutics, and clothing and textiles; on the other hand, as partners to these three sectors, special attention must be paid to manufacturing involving plastics, paper and cardboard as well as metal mechanics.

National Innovation, Science and Technology Policy—It has significantly updated the STI policy framework and the Technical Secretariat of the Presidency, the Ministry of Economics, and the Ministry of Education have recently completed the preparation of the National Innovation, Science, and Technology Policy (PNICT).[41] This policy has compiled a new reference framework for the promotion and coordination of scientific and technological research, as well as for innovation promotion. It also includes principles and guidelines for confronting the country's challenges: scientific formation, the creation of a new research, development and innovation (R&D&I) system, and the strengthening of institutionalism and STI infrastructure.

The policy has the main objective of promoting and coordinating research and development (R&D) with the aim of contributing to sustainable development and social well-being. Its specific objectives and strategies include (1) generating public goods and strengthening an environment that facilitates R&D&I; (2) strengthening

[40] STP/MINEC/MAG/BCR/ASI (2011).

[41] STP/MINEC/MINED (2012).

R&D&I as well as precompetitive research; (3) supporting business innovation in order to increase competitiveness; (4) stimulating innovative entrepreneurship; and (5) diffusing and promoting the adoption and absorption of technology.

From an institutional perspective, it has been proposed that the National Innovation, Science, and Technology System (SNICT) be formed by an articulated set of public, private, and business organisms. This includes the academy and other organizations which coordinate, execute, develop, and evaluate actions and functions for the innovation and development of competencies. Likewise, the PNICT proposes the necessary institutionalism for the adequate operation of the system. This has included the creation of an Inter-Ministerial Committee for Innovation, Science, and Technology and of an Inter-Ministerial Innovation, Science, and Technology Coordination Unit of the National Innovation, Science, and Technology Observatory, among other organizations. The first would act as an entity for directing and coordinating, whereas the second is a technical operative organ, recognizing the role of the ministries whose activities are related to STI activities, mainly the MAG, the MINEC, and the MINED, as well as the coordinating role of the STP.

Finally, the policy makes reference to the need for the creation of a new regulatory framework which establishes the rules in order to guarantee the development of STI activities. Negotiation with multilateral and bilateral international financing agencies is also proposed, in order to be able to channel sufficient funds for the creation of an innovation, science, and technology base. As part of the above, the government of El Salvador negotiated a loan from the Inter-American Development Bank (IDB) for 30 million dollars during 2012, which was granted in November of the same year.[42] This loan will finance the design and implementation of the organizational and institutional framework proposed by the PNICT and put new instruments to work for the promotion of investment in technology and innovation, as well as the formation of high-level human resources.

3.2.3 Administrative Framework (Management and Control)

In El Salvador, these functions consist of the commissioning of specific STI activity support programs and projects, as well as the establishment of regulations and follow-up and control systems. These tasks are carried out by the aforementioned ministries, which participate fundamentally in policy design by way of their viceministers and other organisms that are linked to the executive branch through them; the most relevant ones are mentioned below.

Presidency of the Republic—The National Commission for Export and Investment Promotion (CONADEI) is appointed to this, with functions that include the promotion of exports and attraction of foreign investment through its

[42] Source http://www.innovacion.gob.sv/index.php/linknoticias/406-el-salvador-mejorara-sus-capacidades-de-innovacion-y-productividad-con-un-prestamo-de-us30-millones-del-bid-.html, retrieved in November, 2012.

entities EXPORTA and PROESA, respectively. The latter has been operating since 2000, while EXPORTA has been operating since 2004.

Ministry of Agriculture and Farming—Besides the activities of promotion and support in corresponding areas (including fishery) and management of the CENTA, the MAG operates one of the components of the Agro-business Reconversion Project, formed by the National System of Alliances for Technological Innovation (SINALIT) whose objective is to strengthen the country's capacity for research and transfer of agricultural, agro-industrial, and forestry technology. The alliance system is supported by funds from the Inter-American Development Bank, and its beneficiaries are agricultural producers and their organizations; agro-industrial companies and other participants in the agricultural production chains; and other technological service providers and generation entities, both public and private and nationally and internationally.

Ministry of the Economy—The Vice-Ministry of Industry and Trade and its Directions of Quality and Production and of Technological Innovation and Development (DIDT) carries out several innovation promotion programs, mainly through the latter, with the objective of contributing to the creation and improvement of conditions that propitiate and facilitate the strengthening of business skills, in order to improve competitiveness. At the same time, it attempts to coordinate with other entities and programs of the Ministry of Economics associated with activities of innovation. This is the case of the National Commission for Micro and Small Enterprises (CONAMYPE), whose function is to foster an array of modern and competitive micro- and small companies, as well as the Direction of Export Promotion (FOEX), whose mission is to strengthen the competitiveness of micro-, small, and medium companies, by way of non-reimbursable co-financing of up to 70 % of the total cost of a project or a punctual initiative regarding the development of exports, quality, liaison, productivity, and innovation, including the adoption and incorporation of technological improvements.

Another important function of the previously mentioned DIDT corresponds to coordinating the design and commissioning of the Technological Innovation System in its regulatory, institutional, and operative phases, as well as the formulation of the Technological Development Master Plan, for the short, medium, and long terms; the National Technological Development Policy and its implementation strategy; programs for strategic economic activities; and the creation and commissioning of the instruments and support mechanisms for Salvadoran business sectors.

The Vice-Ministry of Industry and Trade also governs the General Directorate of Statistics and Census (DIGESTYC), which has the objective of coordinating and producing statistical national social and economic information. However, the STP has advanced adequately concerning its proposal for the formation of a National Statistics System (SEN) and an Official Statistics Law (LEO).[43] These modifications will promote the integration of statistical processes from various

[43] The LEO and the constitution of the CEN were expected to be approved toward the end of 2012.

ministries of government of El Salvador and the transformation of the DIGESTYC in the Salvadoran Statistical Institute—governing body of this system.

There are also various autonomous organisms linked to the executive branch by way of the MINEC. Among these, those most closely related to innovation activities include the above-mentioned CONAMYPE; the National Registry Center (CNR), which among other functions is in charge of registering intellectual property; the General Superintendence for Electricity and Telecommunications (SIGET), regulatory body of this sector; and the Salvadorian Corporation of Investments (CORSAIN), which has the function of promoting and developing companies and firms involved in industrial activities.

Ministry of Education—This ministry is responsible for the operation of the educational system at all levels, and in terms of R&D support, it has recently operated the Higher Education Research Fund (FIES).[44] Likewise, the Vice-Ministry of Science and Technology has taken on the functions of the scientific and technological component of CONACYT and also taken charge of the education technologies and technical, scientific, and technological education, while projecting ongoing activities related to its execution, such as the creation and operation of national research centers involved in exact and social sciences and the creation of technological parks. Besides this, under the initiative of the S&T VM°, the constitution of a National Science, Technology, and Innovation Observatory is being studied, based on the functions of CONACYT's science and technology information collection, and it also intends to carry out activities of science and technology foresight and intelligence.[45]

3.2.4 Regulatory Framework (Regulation)

The only legal ordinance known to be specifically oriented toward STI activities is the previously mentioned CONACYT Law,[46] although currently this is not valid, due to the structural changes in government we have mentioned. A draft law for Scientific and Technological Development has been in the process of development and analysis since 2010, but was not yet approved at the time this work was written.[47] However, this proposes a series of ordinances that no longer occur in practice. Most importantly, it has been established that the Vice-Ministry of Science and Technology is the governing entity for science and technology, responsible for coordinating the formulation and implementation of national science and technology policy, serving as a basis for the preparation of the National Scientific and Technological Development Plan, mentioned previously.

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[44] See Sect. 4.1.3.

[45] The creation of the observatory is also contemplated in the National Innovation, Science, and Technology Policy mentioned in the previous section.

[46] See Foot note 36.

[47] However, it is already being analyzed by the legislative branch. The project to which we refer below dates back to March 2011.

The draft law also contemplates the following relevant actions:

- The constitution of the National System of Science, Technology and Innovation (SINACTI).
- The establishment of the National Science, Technology and Innovation Observatory.
- Actions in the educational sector, which include the following: (1) the modification of study programs, in order to include technological scientific education as a fundamental axis of education; (2) strengthening of graduate studies and implementation of scholarship programs; (3) the mandatory rule for foreign companies based on technology to include Salvadoran research personnel; and (4) the establishment of a National System of Researcher.
- The establishment of funding in addition to that assigned to the education budget, with an amount greater than or equal to 0.1 of the GDP, aimed at STI institutional strengthening.
- Strengthening of international cooperative actions in STI.

The Law for Production Promotion and the Law for the Establishment of the Salvadoran System for Quality (SSC) were directed more toward the creation of environmental conditions. The first has the objective of strengthening production sectors in order to promote sustainability and competitiveness of firms, among other aspects. It includes two fundamental objectives: (1) to establish the bases for the MINEC to develop comprehensive long-term policies oriented toward strengthening innovation and competitiveness, creating a multisectorial coordination mechanism, and implementing specific programs within the planning framework and (2) to promote production diversification, quality, productivity, and innovation in companies, as well as an environment that promotes their establishment.[48]

With this objective in mind, the law created the Integral Business Production Promotion System, coordinated by MINEC, which will promote 12 programs, including quality and productivity, innovation and technology, financing, attraction of investment, and business intelligence. In order to monitor the system's operation, a Committee has also been created, formed by the government agencies and ministries involved in the activities of production promotion, development banking, representatives of production and commercial sectors and the academy. The Ministry of Economics is also responsible for managing any funds, either internal or external, required for addressing the proposed programs.

The second law, regarding quality, has the objective of creating and regulating the El Salvador quality system, incorporating the country's infrastructure involved in promoting competitiveness in the production and services sector, while at the same time contributing to consumer protection. For this purpose, an organizational and regulatory structure for the system has been established, with five autonomous entities:

- The National Quality Council (CNC), a multisectorial body which governs the system, whose administrative office (the OAC) supports the following entities:

[48] Law of Production Promotion, Decree N° 598, January 31, 2011.

- the Salvadoran Regulatory Organism (OSN);
- the Salvadoran Technical Regulation Organism (OSARTEC);
- the Salvadoran Accreditation Organism (OSA);
- the Metrology Research Center (CIM).

Aspects considered by this law include social well-being and development of a culture of quality, the harmonization of guidelines, principles and terms related to quality, and technical support for the execution of programs directed toward strengthening the competitiveness of MSMEs.[49]

Other legal orders that influence innovative activities—mainly by facilitating and by stimulating national and foreign production investment—include the following: the Law on Industrial and Commercial Free Zones; the Investment Law; Law on International Services; and the Tourism Law. The first is aimed at regulating the operation of Free Zones and Free Warehouses for Inward Processing (national territory area, subject to special customs treatment), as well as benefits and responsibilities for company owners who develop, manage, and use these. This allows the establishment of national or foreign companies, dedicated to production, assembly, manufacturing, processing, transformation, or trade of goods, which may be destined for direct or indirect export or future nationalization. The Free Zones Law grants various benefits and tax incentives to individuals or company owners, who develop, manage, or are established in these areas.[50]

The Law on Investment promotes investments in general, but specifically foreign investments, in order to contribute to the social and economic development of the country, by increasing productivity, job creation, export of goods and services, and production diversification. It promotes facility of procedure, equality for investors, and freedom to invest, as well as granting rights, and guarantees for the transfer of funds abroad, residence in the country, access to local financing as well as protection and property security.[51]

The International Services Law is in charge of regulating the establishment and operation of services, parks, and centers, as well as benefits and liabilities of company owners who develop, manage, or operate these companies. This law grants tax benefits and incentives to national and foreign investors in areas of international distribution, international logistic operations, international call centers, information technologies, research and development, maintenance and repair of maritime vessels and aircraft, business processes, physician–hospital services, and international financial services.[52]

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[49] Law of Establishment of the Salvadoran Quality System, Decree N° 790, Official Gazette, August 26th 2011.

[50] Law for industrial Zones and Legislative Commercial decree N° 405, Official Diary, September 1998 (with reforms in May 2009).

[51] Law for Investments, Legislative decree N° 732 Official Diary November 11, 1999 (with reforms in February and March 2000).

[52] Law for International Services, Legislative decree N° 431, Official Diary, October 25, 2007.

4 Science, Technology and Innovation Policy Instruments

Below, we present a brief description of the main STI policy instruments that have been used recently in El Salvador. For this purpose, we will employ a classification based on the nature and characteristics or deployment mechanisms of the instruments; that is, whether measurements are direct or indirect, as well as the type of financing implied. We must not forget that for them to operate satisfactorily, it is also necessary for a series of environmental conditions to exist, including, among other aspects, macroeconomic conditions, competency policies, an education system, infrastructure, a set of industrial standards and regulations, and an intellectual property system.

4.1 Direct Financing Measures

4.1.1 Public Research

Research activities in El Salvador are carried out mainly by the National Agricultural and Forestry Technology Center (CENTA), at some hospitals, and in some of the higher education institutions: universities, specialized institutes, and technological institutes. There are 24 universities in the country (one state university), 6 specialized institutes (one pertaining to the state), and 8 technological institutes (four pertaining to the state); however, according to the information in the CONACYT researcher's records,[53] only 11 universities and 5 institutes are involved in research activities.

Regarding financial resources dedicated to scientific and technological activities (R&D) training in S&T and S&T services, the total invested amount in 2008 was $192,968 million dollars, of which 12.4 % corresponded to research and development and 81.8 % to scientific and technological formation; this therefore implies that total expenditure on R&D as a percentage of GDP was equivalent to approximately 0.1 % (CONACYT 2009), also representing reduced investment. We also have to consider the proportion of this expenditure financed by private higher education institutions.

4.1.2 Human Resources Formation

Although at very low levels, the government of El Salvador operates two funds for higher education: FANTEL scholarships for higher education and the scholarship fund from the Central Reserve Bank, both administrated and executed by private autonomous organisms (the Foundation for Comprehensive Salvadoran Education (FEDISAL) and the Entrepreneurial Foundation for Educational Development

[53] National Science Researcher Records of the El Salvador Researcher Network REDISAL, www.redisal.org.sv, information retrieved in September, 2010.

(FEPADE), respectively). In the case of the second, the fund is supplemented by private donations and international collaboration, managed by the FEPADE.

The FANTEL scholarship program has granted 886 scholarships between 2002 and 2011 (909 if we include 2012); of these, 72 % have been for graduate and postgraduate degrees in El Salvador and 28 % for studies abroad. Between 2002 and 2012, allotted funds reached an amount close to 21 million dollars. For its part, during 2011, the FEPADE granted 4,203 scholarships at various study levels from kindergarten to university education.

Additionally, the recently created Development Bank of El Salvador (BDESAL)[54] has the *SiguEstudiando* program directed toward the development of Salvadoran students by concession of loans and access to quality programs, in order to take courses at medium, higher, technical, and graduate levels in Salvadoran and foreign institutions.

4.1.3 R&D&I Financing Funds

The main funds that have been employed include the FIES and the Production Development Fund (FONDEPRO). The FIES is a mechanism used by the government of El Salvador for concurrent financing of scientific and technological projects presented by certified[55] and State higher education institutions (universities, specialized institutes, and technological institutes), aiming to promote and provide incentives for scientific and technological innovation capacities, as well as promoting the articulation between the academic and productive sectors. In its first call, 7 projects were implemented, with an investment of $409,788.36, and a second call comprised six projects, with the amount of $617,239.59.[56]

The FONDEPRO is a foundation that was formed in 2006 under the Direction of Export Promotion (FOEX) of the MINEC—originally directed toward SMEs—in order to broaden its field of action by incorporating attention lines for microcompanies. The objective of the fund is thus to strengthen the competitiveness of MSMEs, by tending to aspects such as the promotion of quality and productivity, innovation and technological development, and franchise development. Throughout its operation (2002–2012), it has supported more than 1,000 companies with non-refundable co-financing (approximately 50 % of the cost of project initiatives) at a cost of more than 10.6 million dollars (see Graph 14).[57]

Similarly, there are other funds from autonomous organisms such as those managed by the Program for the Promotion of Technological Innovation in SMEs (PROinnova)—one of the four development programs of the Salvadoran

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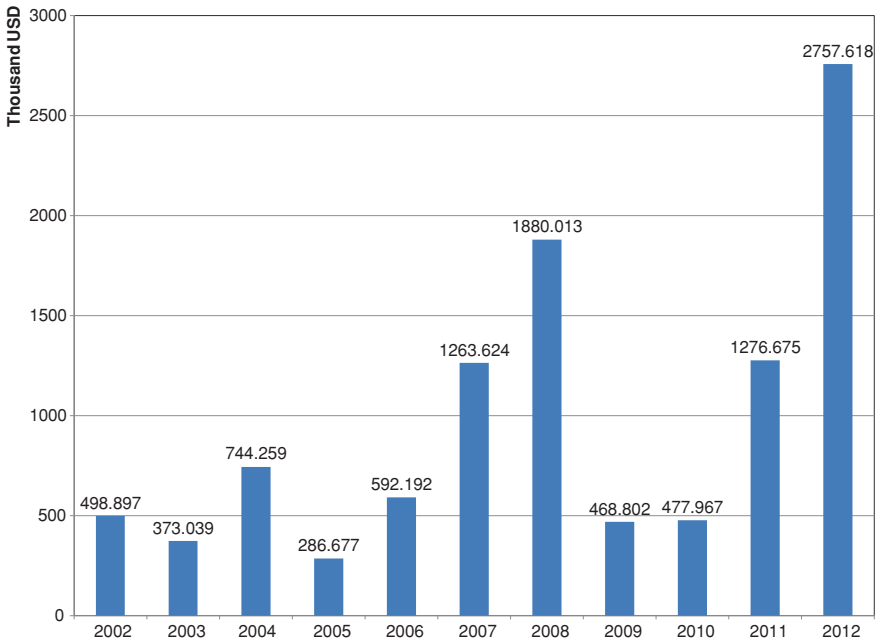
[54] See Sect. 4.4.

[55] Voluntary academic quality certification for higher education institutions; eight universities have this certification.

[56] *Source* http://www.mined.gob.sv/index.php/noticias/1-institucional/4263-seminario-sobre-investigacion-y-presentacion-de-proyectos-fies-.html, information dated December 2009, retrieved in September, 2010.

[57] FONDEPRO (2012).



Graph 14 Amount of FONDEPRO grants, 2002–2012. *Source* Author, based on data from FONDEPRO (2012)

Foundation for Economic and Social Development (FUSADES), a private development organization, but these cannot be considered as part of the policy instruments implemented by the government of El Salvador.

4.1.4 Support for Scientific Infrastructure

This is carried out only through the resources of the normal budget for the CENTA and the public institutions of higher education.

4.2 Indirect Regulatory Measures[58]

4.2.1 Intellectual Property

The National Registry Center is the organism responsible for managing intellectual property, as well as other records. This organism has ISO quality certification; its procedures have been well systematized and digitalized since 2008—although it

[58] These instruments all evidently form part of the environmental conditions.

does not have online search services and carries out its tasks according to internationally set times.[59] It has limited capacity for disseminating the advantages of intellectual property, reflected in a scarce inclination to use the various forms of protection and low use of these as technological information sources.

4.2.2 Quality System

Until recently the organism responsible for this function was the CONACYT, which as previously indicated has been transferred to a new organism within the Ministry of Economics: the National Council for Quality, designed to coordinate the functions of four agencies responsible for metrology, accreditation, standardization, and technical regulation. The fieldwork carried out between 2010 and 2011 revealed limitations in terms of capacity for international certification within the pharmaceutical sector.

4.2.3 Tax Incentives

Incentives of this nature have already been mentioned, particularly those directed toward attracting investment; however, in the case of the promotion of R&D&I, to this day, they have not been instrumented. However, the PNICT states among its strategies for achieving specific objectives, the design and implementation of a tax and non-tax incentive schemes for the development of the infrastructure linked to STI activities, as well as the promotion of investment for innovative projects.

4.3 Other Direct Measures

4.3.1 Scientific and Technological Information Services

This area has basically been covered by CONACYT, both through the Technological Information Center and through the compilation of STI indicators statistics and generation, and other diffusion services. Likewise, the Technological Innovation and Development Direction undertakes efforts in this context (Sectorial Cells, for example). Also, the DIDT, together with the DIGESTIC, has worked during the last year on the preparation of the first formal survey on innovation in El Salvador, which will help to complete information on STI, which still presents limitations.

It is important to also describe services that will be rendered by the National STI Observatory. Its creation is contemplated in the PNICT along with the draft law for Scientific and Technological Development, and although its design and instrumentation

[59] We must not forget that the demand for intellectual property services is low in El Salvador.

details have not yet been defined, the Vice-Ministry of Science and Technology received technical assistance from the World Bank for this purpose. The conclusions from this technical assistance indicate the need to create an organism with multiministerial participation, exploiting the institutionalism proposed by the PNICT, as well as the creation of the Salvadoran Statistics Institute, for consolidating STI information collection, as well as providing scientific and technological and prospective intelligence services to the business and academic sectors.[60]

4.3.2 Promotion of Diffusion Networks and Schemes of Entrepreneurial and Innovation Culture

The main instruments detected in this section correspond to the previously mentioned SINALIT, operated by the Ministry of Agriculture; to the programs of the Direction of Technological Innovation and Development within the framework of INVENTA—such as technological extension, sectorial cells, and the attraction of resident experts living abroad; and to some degree, some of the actions coordinated by the Salvadoran Institute of Professional Formation (INSAFORP), a governmental institution responsible for the direction and coordination of the National Professional Formation System. However, overall, efforts are still modest, and as mentioned previously, synergies which could be generated by coordinated action have not been exploited.

4.4 Catalytic Financial Measures

4.4.1 Loans and Guarantee Funds

These are operated through organisms of the state financial system: the El Salvador Mortgage Bank (BH), providing specialized attention for small and medium companies[61]; the Bank for Agricultural Promotion (BFA), whose objectives include attending to the financial needs of micro-, small, and medium enterprises in the agricultural and agro-industrial sector[62]; and the Development Bank of El Salvador (BDES).[63] The latter is a public credit institution, and its principal objective is to promote the development of viable and profitable investment projects from the

[60] World Bank (2012).

[61] In March 2010, the BH had a total of assets and contingencies of 431 million dollars, BH (2010).

[62] During 2009, the total amount of credit disbursed by the BFA rose to 81 million dollars, BFA (2009).

[63] Result of the transformation from the Multi-sectorial Investment Bank (BMI) concretized in early 2012.

productive sectors of El Salvador, by providing financial and technical support, in order to contribute to (1) growth and development of productive sectors; (2) development and competitiveness of entrepreneurs; (3) development of MSMEs; (4) promotion of exports; and (5) improvement of health and education services.

The BDES administrates an Economic Development Fund (FDE) directed toward financing and co-financing projects within the areas mentioned above, as well as the Salvadoran Guarantee Fund (FSG) fundamentally oriented toward facilitating access to financing productive sectors: micro-, small, and medium firms, by granting surety guarantees and other commitments to pay credit or financial operations. In addition, the BDES has first and second flood banking financing lines. It is currently known that the development bank, together with the DIDT, contemplates the provision of instruments of greater impact, such as risk capital or seed capital, but they have still not provided reportable results.

4.5 Combined or Mixed Measures

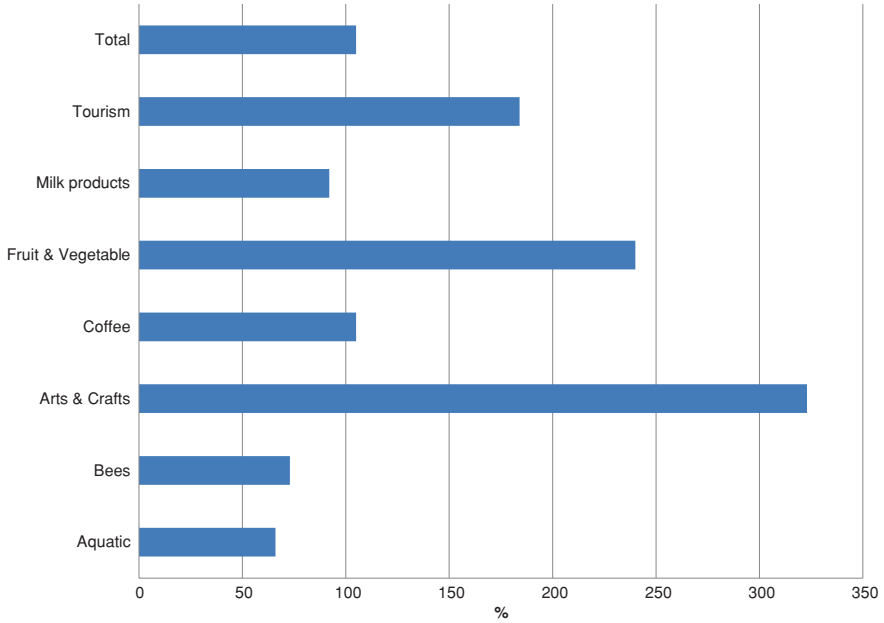
4.5.1 Creation of Industrial Clusters

Some of the actions of the Millennium Fund (FOMILENIO) include goals, which to a certain degree comply with this objective, as well as the SINALIT of the MAG. FOMILENIO was an autonomous entity of technical character, supported by an agreement with the Millennium Challenge Corporation (MCC) to implement a 5-year program with the objective of reducing poverty and achieving economic growth in the northern region of El Salvador. The patrimony of FOMILENIO was created with funds granted by the MCC, proceeding from the government of the United States. The program finalized in September 2012.

As part of the 5-year objective, the Production Development Project was oriented toward turning the northern region into an economic corridor, organized for the production of agricultural foods and tourism services and integrated with the rest of the country, employing qualified human resources in order to attain high productivity. The Production Development Project was divided into three main areas: (1) production and business services; (2) investment support services; and (3) financial services. The value chains supported by the Production Development Project experienced an increase in total annual income (weighted average) of 105 % (see Graph 15).

4.5.2 Foresight

The development of the Quinquennial Development Plan implied an exercise in long-term foresight; however, from the specific perspective of STI, this type of exercise was not carried out with sufficient rigor. Nevertheless, it is expected that as part of the PNICT, a formal prospective study will be carried out, directed



Graph 15 Percentage increase in annual net income of value chains supported by the Production Development Project. *Source* Author, based on data from the FOMILENIO (2012)

toward developing STI, which will allow the formulation of a national innovation, science, and technology plan, in order to establish priority areas to receive the support of STI policy instruments.[64]

4.6 Others

4.6.1 International Cooperation

International cooperation is one of the mechanisms that is most exploited for the implementation of activities benefiting STI activities. Some of the principal actors in El Salvador are the UNDP, German cooperation through GIZ, and Japanese cooperation through ODA.

[64] *Source* Interview with Mr. Yax Canossa Humberstonem, Director of Innovation and Technological Development, carried out in June 2012, within the framework of technical assistance of the World Bank to strengthen institutional capacities for strategic planning of the science, technology, and innovation system in El Salvador.

5 Conclusions

As we have seen, at the beginning of the present government administration (2009–2014), neither of the two systemic conditions existed in El Salvador that would allow for appropriate and sustainable construction of a national innovation system. First, there was no articulated set of STI policies, but instead, isolated policies focused on scientific research, or technological development and innovation, agricultural and industrial development or exports. Additionally, scarce resources were destined toward these activities, in comparison with the Central American and Latin American environment. Second, the knowledge and production generation subsystems have experienced incipient development with low collaboration capacity.

However, between 2010 and 2012, transformations have been made in the institutional framework which could have a positive impact on the development of the production, academic, and research sectors. Let us briefly consider these factors and processes.

5.1 Direction and Vision of Policies

There has not been a government entity or organism to provide cohesion and direction of the policies concerned with STI activities. Consequently, different ministries have proposed policies and regulations that, in spite of being relatively well oriented, do not achieve the complementarity which would multiply their effectiveness. Additionally, industrial policy, innovation policy, and science and technology policy have been dealt with separately. This has not taken into account the actions of the ministries of agriculture, health, etc., in terms of STI.

At present, if the proposed initiatives in the National Innovation, Science, and Technology Policy are formalized, this responsibility will fall on the Inter-Ministerial Committee for Innovation, Science, and Technology, with the articulated participation of the main ministries whose tasks are closely related to STI activities. The PNICT implies a significant step, not only regarding the governance of this area, but also the enrichment of applied policy instruments. The fact that the recent loan was linked to the IDB in a series of organizational and institutional transformations, as well as specific promotion projects associated with the PNICT, may imply the guarantee that it can be instrumented independent of the change in government administration which will take place in 2014.

Regarding foresight, the Quinquennial Development Plan has been implemented, representing the country's outlook and development project, but this excellent work lacks specific, detailed programs (at least regarding STI). What has existed, at least since the 2006 CONACYT document, and including the recent National Plan for Scientific and Technological Development, are plans that are too broad and ambitious. For example, the aforementioned document included 13 areas of knowledge for scientific and technological development, whereas in the second, 29 areas and 156 strategic lines were proposed. Taking into account R&D expenditure in the

country and the number of researchers (approximately 500) and personnel dedicated to this, these plans are simply impossible to carry out. If a formal prospective survey[65] exercise is carried out and a new National STI Plan is prepared, more relevant plans and policies may be implemented that deal with the country's reality and needs.

Within this subject, the comprehensive export support strategy is a much more realistic proposal, with goals that are obtainable, as well as concrete programs and instruments. However, it is not clear how the strategic objective and areas intended to receive support have been defined, especially those where the country does not currently have the necessary skills. Likewise, the document presents certain inconsistencies, both in terms of lines of action which do not completely correspond to the programs and in terms of instruments, or because elements which link strategic goals to the programs are missing, as well as progress indicators which could direct follow-up and necessary adjustments.

5.2 Management and Control of Policies

Regarding management, the fundamental problem has been the lack of articulation and policy alignment between the principal government organisms. Given the limited amount of policy instruments and resources, their management has not presented problems and the appropriate organisms are available for satisfactory compliance of the necessary functions. Additionally, a growing trend has been observed consisting of promoting articulation mechanisms between different actors involved in the science, technology, and innovation system. Nevertheless, the linear model is still predominant, with initiative dedicated toward strengthening the skills of actors in an isolated and non-systemic way. Nonlinear policies are still scarce, such as the promotion of liaison between universities and businesses, and the creation of offices for the transfer of technology, and business incubators (Padilla Pérez 2013).

Something similar may be said regarding most legal and regulatory aspects. However, the more important issue would seem to correspond to the eventual approval of a law directed specifically toward science, technology, and innovation. The draft of the Law on Scientific and Technological Development (LDCyT) that we know, although it has several very positive actions, also includes aspects or actions which may be problematic or were even formulated in an ambiguous way. Among these, it is worth mentioning:

- The hierarchical location of the STI Rectory, at the level of vice-ministry, and as a part of the educational sector. This issue is problematic not only because it duplicates an unsatisfactory experience (CONACYT), but also because it contradicts the PNICT, which recognizes the multifactorial nature of STI.
- The constitution by law of the National Innovation, Science, and Technology System (a relatively common practice in Latin America and generally unsuccessful) which reflects an equivocal interpretation of the systemic views applied to STI.

[65] See Sect. 4.5.2

- Additionally, the project makes reference to the Innovation Law,[66] which should be presented to the Ministry of Economics; however, the LDCyT draft defines both laws as complementary. However, it would appear to be difficult to reach an agreement concerning the limits of the functions of the two ministries involved in the subject of innovation.

Another relevant aspect where there are great shortcomings relates to follow-up, evaluation, and adjustments (control) carried out together with the applicable STI policy measures. In fact, a number of fieldwork projects have detected the lack of a culture of evaluation. This lack of monitoring and evaluation refers to all levels, from policy design to implementation through programs and projects, and includes an insufficiency of preliminary diagnostics, as well as formal progress follow-up and impact evaluation methods. Examples of these flaws are as follows:

- Creation of new research centers.[67] In this sense, there is no known diagnostic that justifies their creation, especially given the lack of resources; it might be preferable to strengthen the infrastructure and personnel of existing public research organisms.[68]
- Project for creating a "technological park," without a preliminary analysis that includes a comparison between success and failure of this type of initiative in Latin America, and the viability of implementing one in El Salvador. Additionally, the information provided on this subject by the VM° of Science and Technology is very scarce and it refers more to the park's intended reality, but among the proposed functions, little similarity is perceived in terms of what a technological park actually consists of.
- Industrial policy, which although it includes a preliminary diagnostic reveals methodological inconsistencies.[69] On the other hand, the policy proposal does not define innovation as its axis, and specific instruments do not include aspects of evaluation and follow-up from the design stage.

[66] And there is no reference or knowledge of this.

[67] A recent work report (MINED 2010a) reports the creation of the El Salvador Scientific Research Center and the National Social Sciences Research Center, as well as research projects carried out.

[68] The "Research Centers" are in fact virtual, entirely consisting of academic personnel from the University of El Salvador, and in these, no formal evaluation processes are managed for the selection and control of the research projects which will be carried out. Source: Interview with members of the centers, carried out in February 2012, within the framework of technical assistance of the World Bank to strengthen institutional capacities for strategic planning of the Science, Technology, and Innovation system in El Salvador.

[69] Mix of different economic reference frameworks that are not always compatible.

5.3 Final Considerations

Based on the analysis carried out, we perceive on the one hand a strategic redefinition adopted by the government of El Salvador and, on the other hand, an effort to build an institutional architecture that responds to the present challenges. Instead of the exclusive use of traditional incentive mechanisms for supply or demand, a broader repertoire of instruments has been observed, which a few years ago was non-existent. These include technological funds, sectorial funds, stimulus for risk capital by way of the new Development Bank of El Salvador (BDES), and promotion initiatives regarding the university–business relationship. All of these are commendable in terms of design, whereas their performance, implementation, and evaluation are another matter. Thus, the general diagnostic is robust: The main problems and weaknesses of the STI policy instruments in El Salvador do not relate to design, so much as they do to implementation, monitoring, creation of performance indicators, and the evaluation of results.

By reviewing the operation of each instrument, we were able to determine that the intentionality of these is well defined, but evident inconsistencies and overlaps persist in relation to the various plans, programs, policies, and instruments. For example, there are few goals and many strategies, and these are not all consistent with the existing instruments—either in number or in scope. The diagnosis suggests that a wide range of instruments still exist for the promotion of science, technology, and innovation activities, including tax incentives, risk capital, and government procurement.

In other words, management mechanisms permitting STI policies to be reviewed, adjusted, or updated, as a result of immediate feedback, are still lacking. To this, we add the persistent problem of "dynamic inconsistency" or temporary incongruence between the implementation and evaluation of results, basically due to pressure on the part of the government to deliver results in the short term as well as committing to systemic long-term actions.

However, in the last 4 years (2009–2012), the government of El Salvador has undertaken great efforts to transform its organizational, regulatory, and policy frameworks regarding science, technology, and innovation. Although it is impossible to evaluate the results because some of the more important modifications were proposed or commissioned a year ago or less, it is apparent that institutional redesign appears to be adequate for the specific conditions of the country.

In the first place, a landscape of illusory and highly ambitious (not real) plans is being replaced by a situation that directs its attention to areas, goals, and objectives that are more attainable. Secondly, there is a tendency toward the generation of synergies by way of feedback regarding the objectives of various entities that previously operated in an uncoordinated fashion. Thirdly, the restructuring of the development bank will allow more economic agents to have access to resources for development and innovation projects. Finally, a disposition for change and for the search and exploration of new STI policy instruments that improve the environment where knowledge and innovation are created can be perceived.

Despite the observed strengths and weaknesses, there are a great number of STI capacities that show potential for being advanced and built-up with successful results. Scientific research is ongoing, especially in the area of health sciences. There are

also certain nuclei for formation that are of excellent quality. Innovative companies appear to be gaining in experience, and collaboration between university and businesses shows positive signs, for example in the design of specific study programs. There is interest in different environments for the promotion of science, technology, and innovation, from different public institutions, non-governmental organisms, and international cooperation. Finally, the bases for the legal framework are appropriately established in order to prevent them from inhibiting innovative activity.

The country also has a number of factors that provide opportunities for the development of skills in science, technology, and innovation. El Salvador possesses good roads, aviation, and telecommunication infrastructure. There are also national programs, such as the La Unión Port, or the new Fomilenio II, which offer opportunities for the development of technological and innovation skills. The dominant presence of Salvadorans abroad also provides a route of access for valuable resources and knowledge.

Production diversification provides opportunities for progress in many areas, and commercial opening is an incentive for innovation to increase competitiveness, facilitate the procurement of capital goods, and access new technologies. International cooperation contributes importantly to the development of innovation skills, and there are opportunities for greater international collaboration regarding research and innovation. Finally, the country has reached broad consensus regarding the continuity of macroeconomic policies for stability and trade opening, fortifying trust on the part of the private sector (national and foreign) for investment in the country.

However, the country must take on the challenge of developing STI skills in a context where public resources are scarce. Business heterogeneity, where there is a wide micro and small company sector with low productivity, will also limit the country's potential for fulfilling STI objectives. Consumer culture acts as a disincentive to production investment, augmenting international competitiveness; thus, among other factors, a lack of greater capacity for technological absorption will create difficulties for Salvadoran companies. Finally, we must not forget the cost and fragility of the country regarding delinquency, natural disasters, and external impacts.

References

Andersen ES (1994) Evolutionary economics: post-Schumpeterian contributions. Pinter, London

Beer S (1972) Brain of the firm: the managerial cybernetics of organization. Allen Lane/The Penguin Press, London

Beer S (1979) The heart of the enterprise. Wiley, Chichester

Beer S (1984) The Viable System Model—Its Provenance, Development, Methodology and Pathology. Journal of The Operational Research Society 35(1):7–25

BFA (2009) Memoria de labores 2009. Banco de Fomento Agropecuario, San Salvador

BH (2010) Informe Financiero Trimestral al 31 de Marzo de 2010. Banco Hipotecario de El Salvador, San Salvador

Cáceres LR, Saca NN (2006) What Do Remittances Do? Analyzing the Private Remittance Transmission Mechanism in El Salvador. IMF Working Paper. IMF

Economic Commission for Latin America and the Caribbean (2009) La inversión extranjera directa en América Latina y el Caribe, 2008. Santiago de Chile

Economic Commission for Latin America and the Caribbean (2010) Innovar para Crecer. Desafíos y oportunidades para el desarrollo sostenible e inclusivo en Iberoamérica
Economic Commission for Latin America and the Caribbean (2011) Balance preliminar de las economías de América Latina y el Caribe
Checkland P (1981) Systems thinking, systems practice. Wiley, Chichester
CONACYT (2006) Política Nacional de Ciencia, Tecnología e Innovación. CONACYT, San Salvador
CONACYT (2009) Indicadores de ciencia y tecnología. Estadísticas sobre actividades científicas y tecnológicas. Sector de educación superior y gobierno. CONACYT, San Salvador
Dalum B et al (1992) Public policy in the learning society. In: Lundvall B-A (ed) National systems of innovation: towards a theory of innovation and interactive learning. Pinter, London/New York
David P, Foray D (1994) Accessing and expanding the science and technology knewledge base. A conceptual framework for comparing national profiles in systems of learning and innovation. OECD, Paris
DIGESTYC (2005) VII Censos Económicos 2005. Ministerio de Economía, San Salvador
Edquist C (1997) Systems of innovation: technologies, institutions and organizations. Pinter, London/Washington DC
Edquist C et al (1998) The ISE Policy Statement—The Innovation Policy Implications of the 'Innovation Systems and European Integration' (ISE) Research Project. European Commission, Linköping
FOMILENIO/MCC (2012) Servicios de producción y negocios. Informe Final Proyecto de Desarrollo Productivo. FOMILENIO/MCC, San Salvador
FONDEPRO (2012) Resultados al 31 de octubre de 2012, Ministerio de Economía de El Salvador, San Salvador. http://www.fondepro.gob.sv/index.php/institucion/antecedentes. Accessed Nov 2012
Freeman C (1987) Technology policy and economic performance: lessons from Japan. Pinter, London
Freeman C (1995) The National System of Innovation in Historical Perspective. Camb J Econ 19(1):5–24
Freeman C (2002) Continental, national and subnational innovation systems—complementarity and economic growth. Res Policy, 31(2) 191–211
Gobierno de El Salvador (2010) Plan Quinquenal de Desarrollo 2010–2014. Secretaría Técnica de la Presidencia, San Salvador
Law of Production Promotion. Decree 598. January 31st 2011
Ley de Creación del Sistema Salvadoreño para la Calidad. Decreto 790. Diario Oficial, 26 August 2011
Ley de Inversiones, decreto legislativo 732. Diario Oficial, 11 November 1999
Ley de Servicios Internacionales, decreto legislativo 431. Diario Oficial. 25 October 2007
Ley de Zonas Francas Industriales y de Comercialización, decreto legislativo 405. Diario Oficial, 23 September 1998
Ley del Consejo Nacional de Ciencia y Tecnología. Decreto Legislativo 287. Diario Oficial, 10 August 1992
Lopez-Martinez RE (2010) El enfoque de sistemas y su aplicación en los estudios económicos sobre la innovación. In: Corona L (ed) Innovación ante la sociedad del conocimiento. Disciplina y enfoques. Facultad de Economía UNAM/Plaza y Valdez Editores, Mexico, pp 263–289
Luhmann N (1995) Social systems. Stanford University Press, Stanford
Lundvall B-A (ed) (1992) National systems of innovation: towards a theory of innovation and interactive learning. Pinter, London/New York
Lundvall B-A (2002) National systems of production, innovation and competence building. Res Policy 31(2):213–231
McKelvey M (1991) How do national systems of innovation differ? A critical analysis of Porter, Freeman, Lundvall and Nelson. In: Hodgson GM, Screpanti E (eds) Rethinking economics: markets, technology and economic evolution. Edward Elgar, Aldershot/Brookfield
MINEC (2010) Estrategia integral de fomento a las exportaciones. Ministerio de Economía, San Salvador

MINED (2010a) Memoria de labores 2009–2010. Ministerio de Educación, San Salvador
MINED (2010b) Plan Nacional de Desarrollo Científico y Tecnológico. Marco de Ejecución de la Agenda Nacional de Investigación. Ministerio de Educación, San Salvador
Nelson RR (1993) National innovation systems: a comparative analysis. Oxford University Press, New York/Oxford
Nelson RR, Nelson K (2002) Technology, institutions and innovation systems. Res Policy 31(2):265–272
OECD (1992) Technology and the economy: the key relationships. OECD, Paris
OECD (1994) The OECD jobs study. Facts, analysis, strategies. OECD, Paris
OECD (1999) Managing National Innovation Systems. OECD, Paris
OECD (2002) Dynamising national innovation systems. OECD, Paris
Padilla Pérez (ed) (2013) Sistemas de innovación en Centroamérica. Fortalecimiento a través de la integración regional. Libros de la CEPAL 118. ECLAC, Santiago de Chile
Soete L, STRATA-ETAN Expert Group (2002) Benchmarking national research policies: the impact of RTD on competitiveness and employment (IRCE). European Commission, Brussells
STP et al (2011) Política industrial 2011–2024. Ministerio de Economía, San Salvador
STP (2012) Política nacional de innovación, ciencia y tecnología. Gobierno de El Salvador, San Salvador
UNCTAD (2007) The Least Developed Countries Report 2007. Knowledge, Technological Learning and Innovation for Development, New York/Geneva
UNCTAD (2010) Investment Policy Review. El Salvador. United Nations, Geneva
UNCTAD, ECLAC (2011a) Examen de las políticas de ciencia, tecnología e innovación. El Salvador. United Nations, Geneva
UNCTAD, ECLAC (2011b) Science, Technology and Innovation Policy Review. Peru. United Nations, Geneva
UNDP (2010) Informe de Desarrollo Humano. El Salvador 2010. De la pobreza y el consumismo al bienestar de la gente. Propuestas para un nuevo modelo de desarrollo.
Von Bertalanffy L (1968) General system theory: foundations, development, applications. Braziller, New York
WEF (2011) The Global Competitiveness Report 2010–2011. WEF, Geneva
WEF (2011) The Global Competitiveness Report 2010–2011. WEF, Geneva
World Bank (2012) Establecimiento del Observatorio Ciencia, Tecnología e Innovación Salvadoreño. Informe de la asistencia técnica del Banco Mundial pra fortalecer las capacidades institucionales para la planificación estratégica del sistema de ciencia, tecnología e innovación (CTI) de El Salvador. September 2012

Policy Coordination: From FDI to a Broader Framework to Promote Innovation—The Case of Costa Rica

Ricardo Monge-González and Ezequiel Tacsir

Abstract In recent decades, Costa Rica viewed FDI attraction as a strategic option to sustain growth, promote structural change, and create better jobs. The successful record of FDI investment in the country fostered profound changes in the country's trade specialization, inducing derived demands for new and better skills in the population and wider availability of entrepreneurial and technical capabilities in specific industrial clusters. In fact, labor mobility from global to domestic firms has had a positive impact on rate of creation and survival of knowledge-intensive firms in the country (Monge-Gonzalez 2012). However, the linkages between local and foreign companies in Costa Rica are still weak, and R&D and innovation investments are coming short for the country needs (Crespi and Tacsir, Inversion en ciencia, tecnologia e innovación.Proyectando a Costa Rica, Editorial Academica Espanola, Saarbrucken, Germany, pp 18–26, 2012; Crespi, Nota Tecnica sobre el Sistema de Innovacion en Costa Rica. IDB Technical Note, 2010). In this scenario, Costa Rica, joining an emerging world trend, has been shifting gradually toward a more selective policy approach to FDI by targeting certain knowledge-intensive sectors, while some global firms have recently moved toward more sophisticated activities in the country. In fact, the private sector concentrates slightly more than 2,000 employees working on R&D, out of 6,000 that the country totals. The success of this new endeavor

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will depend on the coordination and the capacity to "activate" OCDE (Attracting Knowledge-Intensive FDI to Costa Rica: Challenges and Policy Options, OECD Development Centre, Making Development Happen Series No. 1, Paris, 2012) government policies beyond investment promotion, per se. Public institutions like CINDE have earned a reputation for their success in attracting high-tech FDI and coordination capabilities across the public sector and timely response to specific private demands. Similarly, the more recent creation of the Presidential Council for Competitiveness and Innovation (PCCI) in 2010 aims at improving the governance of this new approach to development, through the coordination of the needed policies. The contribution of this chapter is twofold. First, it will discuss to what extent the national policies and institutions have so far contributed to promote the exhibited upgrading of local operations. Second, it will describe the current efforts to move to a wider development strategy, where the focus is on knowledge-intensive activities and innovation.

1 Introduction

Costa Rica stands as one of the most politically stable countries in Latin America, at the same time that has the most successful economy in Central America. The growth model, based on an open economy that has made foreign direct investment (FDI) the principal engine of the country's dynamism, allowed the country to progressively shift its export composition from primary products to high-tech manufacturing and services.

While FDI has also acted as a demand–push for improving education and training and has fostered learning (at the level of workers, management, and production), it fell short of the promises of a more knowledge-intensive economy. In fact, with few exceptions, domestic companies have not been very successful in providing critical production inputs for international companies. In this regard, the weakly developed domestic production system, lack of international certifications and standards, and concerns quality have acted as the main obstacles. The progressive shift toward more knowledge-intensive areas followed by global companies and a pushed toward a more targeted FDI attraction policy demand a new set of coordinated policies by the Costa Rican authorities.

This chapter is organized as follows. Following this introduction in which a succinct summary of the evolution of Productive Development Policies (PDP) is presented, Sect. 2 describes the main challenges faced by the country in terms of science, technology, and innovation. Section 3 presents the rationale and potentials of the main policies implemented in the country, focusing mostly in the expected effects of FDI. Section 4 summarizes the main effects of FDI due to the vertical linkages, labor mobility, and on the innovation capabilities of domestic firms. Taking into account the so-far limited effects of the development model followed in Costa Rica, Sect. 5 aims at making the case for stronger policy coordination among public agencies. Finally, Sect. 6 concludes.

1.1 Journey Through the Productive Development Policies in Costa Rica

Generally speaking, Costa Rica has implemented PDPs for decades.[1] However, over the last 3 years, the history of PDPs[2] in Costa Rica is characterized by significant changes. In this period, the country experienced a radical swift toward export-oriented strategies and a further integration in which the attraction of FDI became "the development model" for the country.

In particular, during the 1960s, 1970s, and part of the 1980s, Costa Rica followed an inward-oriented economic strategy, based on the restriction of imports of goods in order to protect local industries. As a result, these policies created a significant anti-export bias that impeded technological change, production diversification, and the growth of exports to third markets. Together with the international economic problems that occurred at the end of the 1970s (second oil shock, high international interest rates, and debt crises), these policies led the country to a deep economic recession in the 1980–1982 period, with high levels of inflation and unemployment and overall poor economic performance.

Unlike some other Latin American countries that tended to abandon PDPs in the 1980s in favor of market-based mechanisms, Costa Rica never did so. Instead, the country radically switched the orientation of PDPs to other instruments, sectors, and target markets. Emphasis was rather placed on export-oriented sectors and financial instruments, mostly in the form of tax incentives of different kinds, instead of direct price setting and other similar mechanisms used before the crisis. This new set of policies acted through the provision of economic incentives, as those fiscal credits and income tax exemptions conferred to non-traditional exports and Export Processing Zones (EPZ), which in turn improved the grounds for FDI attraction.

Parallel to the export promotion strategy of the last 2 decades, the attraction of FDI has been a pillar for growth (Monge-González et al. 2010). The creation of CINDE (*Coalición Costarricense de Iniciativas de Desarrollo*) at the beginning of the 1980s was a key achievement in this direction. CINDE is a private organization dedicated to attract FDI and supporting the process of the new export-led economic model. A wide range of industries, including electronic components, electrical equipment, medical devices, software, chemical products, beverages and food preparations, tourism, financial services, and call centers, have been growing and attracting significant foreign investment. FDI has followed a clear increasing

[1] This section is based on Monge-González et al. (2010).

[2] Melo and Rodríguez-Clare (2006) define PDPs as policies that aim to strengthen the productive structure of a particular national economy. This definition includes any measure, policy or program aimed at improving the growth and competitiveness of large sectors of the economy (manufacturing, agriculture); specific sectors (textiles, automobile industry, software production, etc.); or the growth of certain key activities (research and development, exports, fixed capital formation, human capital formation).

trend in Costa Rica over the last 25 years, reaching a stable 6 % of the GDP (Monge-Ariño 2011).[3]

While export promotion and FDI attraction are the most relevant policies developed in recent years, other PDPs have also been implemented. One example is PDPs targeting small and medium enterprises (SMEs). During the Miguel Angel Rodríguez Administration (1998–2002), awareness of the need for a new type of industrial policy for SMEs (as well as the need to coordinate multiple programs in many different organizations with limited coordination) led to the creation of *Programa Impulso*, an attempt to integrate diverse programs, including the following:

- Programs to create linkages between high-tech multinational companies (MNCs) and local firms [*Costa Rica Provee* (CRP)].
- Programs that provided financing and credit for SMEs.
- Programs that provided technical assistance and worker training [at the National Technical Institute (INA) and the Ministry of Science and Technology (MICIT)].
- Technical assistance programs directed by the Ministries of the Economy and Agriculture.
- Deregulation and business creation and promotion (red-tape reduction and regulatory improvement programs), administered formally by the Ministry of the Economy, but in practice with direct connection to the Office of the President.

However, the set of policies have to date proven short of overcoming the some aspects of what could be called "structural duality" of the Costa Rican productive environment. On one side, MNC subsidiaries operate at the edge of the productive frontier although binding constraints in terms of more sophisticated business environment and lack of specialized human capital hinder their efforts to move toward more complex activities in the country. On the other side, domestic SMEs struggle to improve their technical and managerial capabilities that will not only allow them to be active supplies of global firms but innovators on the own right.

When Monge-Gonzáles et al. (2010) studied whether PDPs in Costa Rica in the last few decades have responded to market failures interestingly, they conclude that "for the most part, government failures rather than market failures have been the main justification for PDPs. Even in the presence of market failures, the instruments applied in the policy design are not necessarily the most efficient (according to economic theory), but rather the most politically feasible options (lower political cost)." The extent of the challenges faced by the country (see Monge-González and Hewitt 2008; Crespi 2010; Crespi and Tacsir 2012) in terms of competitiveness and innovation suggest a limited effectiveness of current PDPs to address key issues related to the improvement of the business climate and productivity growth. Moreover, PDPs in Costa Rica emphasized selected interventions, narrow sector policies, and targeted instruments, instead of targeting basic requirements and creating market conditions to improve competitiveness.

[3] Monge-Ariño (2011) highlights that FDI has remained above its long-term average (3 %) during the years in which the WTO rules have been in force.

However, and a way to surmounting this duality, Costa Rica has been shifting gradually toward a more selective policy approach to FDI by targeting certain knowledge-intensive sectors, including knowledge processing services, medical devices and life sciences, advanced manufacturing, and (more recently) clean technologies. Prioritizing knowledge-intensive FDI in Costa Rica means focusing, on the one hand, on attracting new companies operating in these fields and, on the other hand, on creating the conditions to support the upgrading of those operating in the country. At the same time, it is required to deepen the current efforts toward policy coordination to increase the incentives for innovation on domestic SMEs.

2 Challenges on Science, Technology, and Innovation

Costa Rica has the most successful economy in Central America. The growth model it has followed thus far, however, does not seem to be creating the conditions that the country needs to achieve a leap in development (Agosín et al. 2009). Costa Rica averaged 5.3 % annual growth in 2001–2007, the highest growth rate in the region. After 2 years of slow growth due to the international crisis, the country has recovered (4.4 % average growth in 2010–2011), albeit at a lower growth rate than the rest of the region. This, however, is due primarily to an accumulation of productive factors rather than productivity. In fact, recent accounts indicate that productivity is only responsible for a meager 25 % of growth (Monge 2010).

While the reasons for this low productivity are varied, one of the most important reasons is a lack of private investment in innovation. In fact, investment in research and development (R&D) has stagnated at 0.5 % of gross domestic product, while countries with similar levels of development and productive structures average close to 0.9 % (IDB 2010; Crespi 2010). Private-sector participation in investment in innovation is low (only 30 % of national investment in R&D, compared to the usual 50 % in countries at similar levels of development). This shortage of private investment in innovation is related to both the behavior of existing companies and a dearth of newly started technology-based enterprises.

The factors hindering greater private investment in innovation vary by sector. In key sectors for competitiveness due to their emphasis on exports—mainly through the role played by FDI operations—such as advanced manufacturing, medical devices, services, and information technologies,[4] the greatest constraint is the limited availability of advanced human capital. Costa Rica has succeeded in creating a cluster of enterprises in these sectors near the international leading edge of technology, and these enterprises need innovations that are highly intensive in advanced human capital if they are to move forward. Numerous indicators are consistent with this diagnosis. First, the lack of human capital is identified as the main obstacle to innovation by 43.3 % of enterprises in these sectors. Second,

[4] The first two aforementioned sectors grew from 7 to 35 % of all exported goods between 1997 and 2008 (Agosín et al. 2009).

technology and engineering careers have near-zero unemployment (CONARE 2012).[5] Third, wages in these fields are growing 30 % faster than the private-sector average. With demand for human capital so high, one may wonder why companies do not invest in developing it. The main obstacle for the companies is uncertainty in their ability to reap the return on these investments. Multiple studies show that the turnover rate for qualified personnel is about 40 %, two-thirds of which is undesired turnover resulting from resignations (Trejos et al. 2012). In short, these sectors lack advanced human capital, and a market failure is standing in the way of a private-sector solution. Moreover, the technology in these sectors changes so fast that professional skills quickly become outdated, and human capital must be retrained on an ongoing basis.

With regard to human capital formation, despite the country's high rate of enrollment in tertiary education (greater than 40 %), students are not graduating with degrees in the fields with the fastest growing demand by companies. More than 70 % of all students graduate with degrees in the social sciences and education, while fewer than 13 % graduate with engineering and technology degrees (CONARE 2012). This is mainly due to limited supply-side capacities stemming from a lack of infrastructure and faculty. In fact, only 1.1 % of the professionals in these fields hold graduate degrees, and Costa Rica's scientific community has limited capacity to train engineers and technology experts.

OCDE (2012) highlights that although the country produces relatively good-quality graduates, there is significant misalignment between the supply of graduates by area of specialization and the skills required by industry. In fact, Costa Rica's PhD graduates stand out in their preference for the social sciences. Of the 93 PhDs granted by Costa Rica in 2000–2002, all of them except one were in the social sciences. During 2007–2009, Costa Rica managed to more than double the number of PhDs awarded. Still, the more technology-related disciplines are still rare: only 2 % of the total was awarded in natural sciences, and it granted no PhDs in engineering and computer sciences.

In more traditional sectors such as the machine tool industry, plastics, and software, which are dominated by SMEs, the lack of information on best practices for production, organizational management, and design at the international level is a problem that affects 27.7 % of all enterprises (MICIT 2009), hindering the development of quality innovation projects and impacting entrepreneurs' perception of the expected return on these investments. In fact, a comparison between international and domestic firms operating in these sectors in Costa Rica reveals that international companies access information from universities more intensely at the time of innovation (60 % vs. 40 %) and make more intensive usage of experts (75 % vs. 40 %).

The lack of financing in these traditional sectors is also a significant constraint to greater investment in innovation. In fact, 45.2 % of enterprises in these sectors

[5] This estimate excludes biology from STEM. Biology, presents an unusual unemployment rate of around 20 %.

identify a lack of access to financing as the main barrier to innovation (MICIT 2009).This problem stems from an information asymmetry related to the quality of innovative ideas between innovative enterprises and financial institutions and investors. Costa Rica's financial market is small and shallow, and its risk capital segment is not well developed, which compromises its capacity to effectively assess projects seeking financing for risky, intangible investments such as those related to innovation (Agosín et al. 2009). The lack of information and lack of financing feed into each other, and in a context low in quantity and quality of projects, the financial system is not developing the capacities to effectively evaluate innovation projects. Nor is an effective market for business and technological information services being developed for domestic firms. The lack of information and access to financing at early stages also has a severe impact on the influx of new technology-based enterprises.

3 Rationale for Policy Intervention

The literature indicates that the impact of FDI on host-country economic development depends on associated technological and knowledge spillovers. In the latter case, such spillovers depend on vertical linkages, worker mobility, and demonstration effects between MNCs and local firms (Smeets 2008, Saggi 2002). In the case of backward linkages, the existence of knowledge spillovers from FDI that generate positive externalities on local industry might justify government intervention. However, success in attracting high-tech FDI does not automatically lead to the generation of knowledge spillovers related to backward linkages. These depend on the MNCs' interest in sourcing inputs in the host country and the domestic linkage capability of that country. Therefore, the case of backward linkage development must be approached both from the demand side (MNCs) and the supply side (local firms).

On the demand side, there are various points to consider. First, there is the sophistication of the MNC subsidiaries productive processes. More advanced processes could create more and higher-value *local* linkages. Second, corporate policies affect the variety, scope, and depth of the activities pursued by the subsidiaries. In many cases, CEOs of incipient MNC branches do not necessarily pursue linkages with local firms. In the initial stages, facilities construction and operations start-up are central priorities. Similarly, and with respect to procurement policy, local procurement managers frequently look for global suppliers rather than local firms for security reasons (productive process robustness). Besides, local procurement managers usually lack knowledge of local capabilities (high costs associated with the identification of local suppliers). This represents an information asymmetry that limits local linkages (market failure).

On the supply side, local firms are not necessarily capable of supplying goods and services to multinationals due to lack of firm-level capacity (entrepreneurship, technology, production scale, manageable risk, and financing). Even when local

firms are competitive enough to become MNCs suppliers, host-country absorptive capacity depends on the learning infrastructure, institutions, and government policies (Paus and Gallagher 2008). When taking into account the potential for externalities created by FDI, support for linkages between foreign and local companies can generate positive outcomes. That is, government intervention can increase the *probability* of realizing those externalities, since these are not automatically achieved unless local suppliers are effectively linked to MNCs.

Costa Rica has been successful in attracting high-tech FDI. In fact, the targeting in attracting specific areas reflects the belief that coordination failures impede an effective cluster formation. However, the recognition of market failures did not carry over automatically to the development of an effective national linkage capability. In fact, the complementary policy to foster spillovers (through CRP program) has been mostly concerned with information asymmetries. In fact, Costa Rican success has been limited in terms of capturing micro (vertical spillovers) benefits from high-tech FDI. The success in attracting growing quantities of FDI (such as in the Costa Rican case) does not automatically lead to the creation of backward linkages and the advantages of knowledge spillovers.

4 A Detailed Look at the Impacts of FDI

The previous section paid attention to the motives driving an aggressive FDI attraction policy. This section will focus on highlighting the observed results in several dimensions: (a) contribution through vertical linkages; (b) labor mobility; and (c) R&D and innovation capacities in the country.

4.1 FDI and Their Vertical Linkages on Costa Rica

Costa Rica has successfully diversified their exports and markets, exporting nowadays over 4,200 products to almost 150 countries. Since FDI inflows have been linked to Costa Rica's exports, FDI attraction has been one of the key elements contributing to Costa Rica's insertion into global value chains. Perhaps the most notorious part of this process started in the late 1990s, after INTEL established in Costa Rica a plant to manufacture computer microprocessors. This turned out to be an inflexion point in the economic history of Costa Rica, to the extent it has produced a significant change in the structure of exports (Monge-Gonzalez and Gonzalez 2007). As mentioned earlier, the establishment in Costa Rica of firms involved in global value chains (mostly driven by efficiency motives) has been favored by the EPZ regime the country has maintained in place since the early 1980s.

According to CINDE estimates, a total of 173 foreign companies invested in services, advanced manufacturing, and medical devices over 1970–2011. This trend has accelerated in the past decade: 75 % of those companies invested in the

past 10 years and 43 % in the past 5 years. Today, these three industries employ more than 66,200 people, compared with only 7,061 in 2000 (OCDE 2012).

Costa Rica is currently participating in several major global value chains (GVC): electronics, medical devices, automotive, and aeronautic/aerospace. Costa Rica's participation in these GVCs takes place through the exportation of a limited number of products and services (listed in Table 1) produced in the country by around sixty firms, 80 % of which operate in EPZs. Moreover, total exports of the products (i.e., goods) listed in Chart 1 account for about 43 % of Costa Rica's total exports.

The list of GVCs in which Costa Rica is participating is consistent with the country's hard work to focus on attracting FDI to strategic sectors where comparative advantages appear to be stronger. An interesting characteristic of these GVCs is that they tend to seek for economies of agglomeration, which provides ground for more links of the GVCs to consider establishing operations in Costa Rica. However, this success has not yet reached those firms (i.e., domestic) operating outside the EPZ regime.

Monge-Ariño (2011) uses firm-level data to investigate in detail the extent and main features of Costa Rica's participation in GVC, particularly the share of exports that is produced domestically and the relative contribution of different domestic sectors to such domestic component of GVCs' exports. In this sense, the overall average for the domestic component of exports was 36 % in 2009 and the firms' individual scores ranged between 16 % and almost 100 %. In fact, the highest domestic component in these exports is found in services-exporting firms which do not import any intermediate service for their production process.[6]

In fact, the share of local supplies in the DCE is rather low in all cases as well as overall average 9 %), while the aeronautic/aerospace GVC shows the lowest share of local supplies in the DCE (3 %) (Monge-Ariño 2011). In turn, the provision of local services shows a more significant participation in the DCE, with percentages ranging between 10 % (electronics) and 31 % (aeronautic/aerospace), and an overall average of 14 %. Nevertheless, it should be noted that an important share of this services (53 %) is explained by the consumption of local utilities in the production processes. Although such a figure is greatly influenced by the electronics GVC, for which two-thirds of the services purchased correspond to utilities, these figures seem consistent with the relatively intense use of physical capital and a limited interaction with local firms.

[6] The GVCs with the highest average domestic component of exports (DCE) were aeronautic/aerospace and medical devices, scoring 71 and 59 % respectively. In the case of the former, the high average can be explained by the fact that two-thirds of its exports correspond to services activities which score the highest DCE percentages overall. In regards to the latter, the high average DCE seems to respond—at least in part, to the growing domestic capacity to provide some services that had to be purchased abroad in the past. It is worth noting as well that these two GVCs are the ones with the largest range of variation for the firms' individual DCE scores. In turn, the GVC with the lowest average DCE is electronics, which probably responds to the fact that the production of this chain is highly globalized and still receives a considerable share of intermediate inputs from other countries. Curiously, the automotive GVC scored the DCE that is closest to the overall average and at the same time it displays the lowest range of variation across the firms' individual DCE scores.

Table 1 Participation of Costa Rica in global value chains

GVC	Total firms	Firms in EPZ (%)	Main products	Exports 2009 (US$ million)	Share of total exports from Costa Rica (%)
Electronics	10	90	• Computer parts and accessories • Digital microprocessors • Electrical switches Electronic filters for TV sets	2,196.5	25.5
Medical devices	25	80	• Needles, catheters, and equipment for serum infusion and transfusion • Other medical devices • Devices for electrodiagnose • Medicaments put up for retail sale	1,268.8	14.7
Automotive	9	89	• Tires • Shock-absorbing systems for cars • Incandescent lamps and electric tubes • Seats for vehicles and their parts • Lubricant or fuel filters • Plastic manufactures for injection equipment	180.0	2.1
Aeronautic/ Aerospace	16	69	• Design and manufacturing of turbines for airplanes • Design and testing of electronic devices for airplanes • Machined parts for airplanes—printed circuit boards for airplanes •Thermostats • Repair of motherboards for airplanes • Maintenance for helicopters metal coatings for airplane parts Lasers for airplanes	21.9	0.3
Total GVC	59	60		3,667.8	42.6

Source Adapted from Monge-Ariño (2011)

4.2 FDI: Labor Mobility, Managerial Practices, and New Firms

There is some growing body of empirical evidence showing that multinationals have generated knowledge transfer and spillovers to the Costa Rican economy, notably labor turnover spillovers. Monge-González et al. (2011), using social security records from CCSS, found that 39 % of the 41,149 employees that left their jobs in MNC operating under the EPZ regime were hired by the local productive sector. This figure supports the presumption that MNCs might have been generating knowledge spillovers. The majority of these employees changed jobs to the private sector with up to 35 years old. Of this pool of mobile employees, half of those workers (49 %) were absorbed by large local companies and the other half (51 %) by SMEs. In addition, the same authors found that 37 % of managers, 25 % of engineers and 31 % of the technicians working in local suppliers of MNC have previously being part of the global firms operating in the country. At the same time, 27.6 % of the local supplier firms have at least one owner with previous working experience on MNCs.

Another study found that a significant number of workers have moved from multinational firms located in the country either to work in a domestic ICT firm or to start an ICT business of their own. According to the authors, 47 % of the domestic ICT firms examined have at least one owner who previously worked for a multinational firm in Costa Rica. In the case of employees currently working at local ICT companies, 26 % of managers, 9 % of engineers, and 5 % of developers surveyed had previously worked for multinationals in Costa Rica. More than half of domestic ICT firms have multinationals as clients in Costa Rica, and 27.6 % of local suppliers of multinationals have at least one owner who worked for a multinational before.

Four types of commercial relationships between multinationals and local ICT firms can be observed in Costa Rica. These involve the local firms acting as ICT wholesalers or distributors; retailers to final users; value-added resellers (VARs), which provide third-party products and services to final users as parts of packages that also include the VAR's own products and services; or representatives—usually not selling directly but providing local points of contact for firms and individuals. Wholesalers and VARs tend to be associated with the widest range of benefits.

Domestic companies report important benefits from these commercial relationships with MNC ICT companies, such as training in sales and marketing techniques and information about current or possible clients, special events for network formation between domestic ICT companies involved with the same multinational ICT companies, and increased visibility for local partners.

Although Monge-González et al. (2011, 2012) among other were capable of identifying positive spillovers from the hiring of former MNC employees, it is worth mentioning that there is room for strengthening the absorption capabilities of domestic firms. In this direction, it is in great need to improve the skills of the personnel, the firms' innovation capacities, and the drive to participate in exports and integrate into GVC. At the same time, it is required to focus even further the FDI attraction policy to emphasize the FDI associated with R&D activities.

4.3 FDI: Contribution to R&D and Innovation Capabilities

R&D investments in Costa Rica are stagnated around 0.4 % of GDP, while give its structural features should be investing 0.9 %. At the same time, private-sector contribution to R&D is particularly weak. This is particularly severe since the only probable mean of increasing total R&D investment is through a more active participation of the private sector. In here is where the establishment of a more focalized and pro-innovation FDI attraction becomes urgent. Increasingly, emerging economies are starting to host a rising number of R&D centers, possible through a combination of public support and transnational corporations' strategies of opening research laboratories in emerging markets. This is effecting and becoming evident in the rising R&D expenditures in countries such as China, Malaysia, and India. Although Costa Rica has seen a gradual increase in the knowledge content of MNCs' activities, R&D investments are still very low and facing structural constraints in the form of lack of adequate and specialized advanced human capital.

OCDE (2012) reports that—based on FDI Intelligence data—the number of business functions carried out in Costa Rica increased between 2003–2005 and 2009–2011. While manufacturing is still the top activity in terms of number of projects and job creations, it receded in recent years. The 2009–2011 data on greenfield investment projects in Costa Rica shows interesting new entries in the types of activities being carried out, including design, development and testing, R&D, and education and training. However, design, development, and testing accounted for approximately a scant 4 % of total national jobs created by *greenfield* FDI investments. This figure is 50 % smaller than the one for Malaysia (around 6 %). Specifically, as for R&D, it accounts for less than 1 % of total national FDI-created jobs (OCDE 2012). Nevertheless, the private sector nowadays concentrates slightly more than 2,000 employees working on R&D, out of 6,000 that the country totals (MICIT 2012).

5 Toward a More Comprehensive Approach

Costa Rica faces an interesting challenge when implementing comprehensive and consistent portfolio of PDPs. Different agencies take care of different domains of the science, technology, and innovation spheres. As such, the relative influence and capacities of the different agencies and ministries might bias the outcome in terms of policy design. In this setting, Costa Rica requires the need for a more coordinated approach that takes into account both the requirements of FDI attraction with a sustained impetus in promoting the endogenous capabilities of domestic firms (both through supplier development program and on its own) and creation of new firms.

As one of the few Latin American countries endowed with a ministry in charge of science, technology, and innovation, it is in a good position to further align innovation and FDI promotion policies (OCDE 2012). However, the vastly

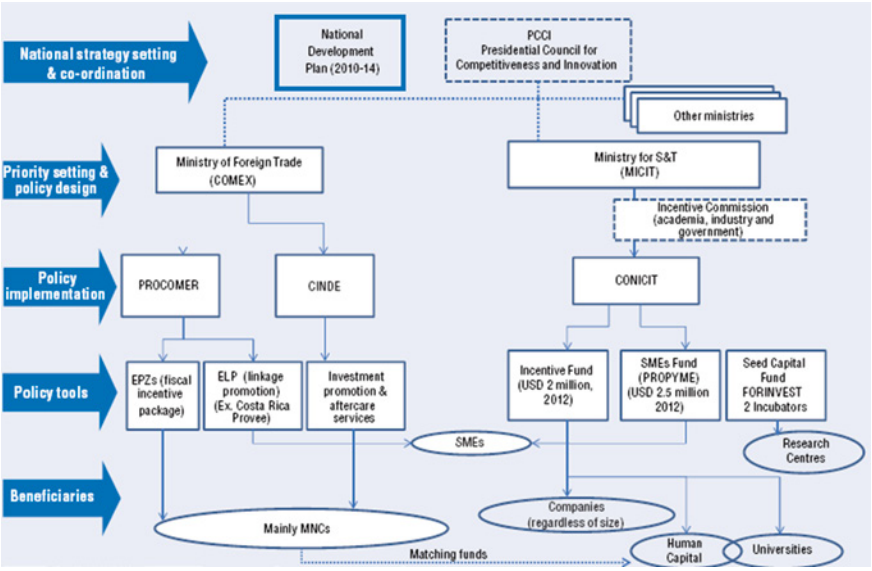

Fig. 1 The governance for FDI and innovation policy, Costa Rica, 2011. *Source* OCDE (2012)

different budget allocations between the foreign trade ministry (COMEX) and the science, technology, and innovation counterpart (MICIT) undermine their potential collaboration. In fact, MICIT is the ministry endowed with the smallest budget envelope in the country.

It should be noted, nevertheless, that the country recently introduced two major institutional reforms to foster higher levels of coordination among FDI and competitiveness policies. In 2011, a cooperation agreement increased alignment between COMEX, particularly through its agency devoted to develop suppliers for MNCs (PROCOMER), the investment promotion agency (CINDE), and MICIT. This agreement, patented on an official document, aims at increasing the efficiency and better use of the PROPYME funds (see 5.1.3), the main window for supporting technological capabilities and innovation projects in SMEs. Although the agreement is too recent to fully assess its impact, it has—together with the operational rules governing the fund allocation—enabled to allocate the highest historical amount for R&D and innovation on SMEs, exhausting the allocated funds in both 2012 and 2013. At the same time, it signals recognition of the need for a more integrated policy approach (OCDE 2012). Secondly, The Presidential Council for Competitiveness and Innovation (PCCI) was established in 2010 and agglutinates 10 ministers and the president of the National Training Institute (INA) who meet on a monthly basis to facilitate policy dialog and information sharing. Figure 1 describes the governance of the FDI and innovation policy currently in place in Costa Rica.

In this setting, the remainder of this section presents the main policies and its actors and suggests how coordination could increase efficiency and maximizes impact.

5.1 Different Agencies and the Need for Coordination

5.1.1 Trade and Investment Promotion

The Ministry of Trade (COMEX) besides creating incentives for FDI also elaborates and manages trade policy. In this way, COMEX integrates foreign investment growth, trade creation, and access to new markets (through free trade agreements) as key objectives of the country's global integration strategy, through two implementing agencies. The Costa Rican Foreign Trade Corporation (PROCOMER) is the implementing agency of EPZ law. It is also responsible for the administration and coordination of incentive contracts with EPZ operating firms, as well as new applicants. The corporation conducts accountability and control processes. However, it is not directly involved in FDI promotion activities. PROCOMER is a public–private organization, whose president is the Minister of Foreign Trade.

The Costa Rican Investment Promotion Agency (CINDE) is a private, non-profit organization responsible for attracting FDI to EPZs as well as non-EPZs. CINDE, established in 1982 as the first Investment Promotion Agency in Latin America, assists foreign investors in their site selection due diligence process (detailed information on the country and its advantages, and organization of customized investment agendas) and manages customized field trips and meetings with service providers, government agencies, industrial parks, and other key organizations. It also offers strategic advice on new operational expansion projects and product diversification. CINDE plays a crucial role in operating as a bridge between investors and the government and providing foreign investors with dedicated aftercare services.

In 2001, CINDE adopted a sectoral focus targeting companies operating in the priority sectors. As a private association, CINDE operates independently and reports to a board of businessmen and professionals, which in turn reports to a general assembly. While its peculiar ownership structure differentiates it from other IPAs, it has a similar operational model (OCDE 2012). Over the years, CINDE has accumulated high-level management and operational capacities and gained a good reputation in the investor community, thereby making it central to the institutional framework for FDI policy. CINDE collects and disseminates relevant information about production and investment dynamics in Costa Rica and serves as an effective channel for voicing private-sector needs to policy makers. Taking into account its limited resources and personnel (see Table 2.5 of OCDE 2012), CINDE seems quite effective compared with other countries.[7] However, should FDI play a more important role in the national development strategy, the organization's operational structure would need to adjust in order to face rising and more diverse source markets and increase its participation abroad.

[7] In between 1997 and 2007, CINDE was responsible for attracting 42 % of the FDI received by Costa Rica and 89 % of the investments attracted through the EPZ regime.

5.1.2 MNC Supplier Development

Together with the emphasis on FDI attraction, Costa Rica established a set of policies supporting backward and forward linkages between domestic and foreign companies. This concern has been there since the creation of the EPZ regime at the beginning of the 1980s (Monge-González and Rodríguez-Álvarez 2012, 2013).[8] In this sense, the National Program of Science and Technology 1986–1990 made also reference to this topic. Notwithstanding public interest, the first efforts to develop local suppliers were initiated by the private sector (MNCs). In fact, Baxter Health Care Inc., one of the first important MNCs established in Costa Rica, created a program of technical assistance for the development of local suppliers in the mid-1990s as a part of the firm's business strategy for the country.

Later, in 1998, local authorities acknowledged the need to develop suppliers, because of the low level of integration of MNCs operating in EPZs with local companies, and to improve the investment climate of the country. As a result, a group of public and private organizations (CINDE, MICIT, PROCOMER, and Baxter) created the Local Industry Improvement Program (Programa MIL) to help local companies do more business with high-tech MNCs. Later, PROCOMER representatives proposed a more ambitious program called Business Linkages Support Program (Profeve), without success.

Specifically, PROCOMER runs a program aimed at matchmaking export companies and local suppliers. Initially, set in 2001 as a pilot program funded by the Inter-American Development Bank, it has focused on "high-technology international companies"; in 2005, it was broadened to include all exporters and got institutionalized under the name of "Costa Rica Provee."

Costa Rica Provee turned into a more MNC-demand-driven program, identifying the main requirements of inputs and raw materials from MNCs and then matching MNCs' demands with local suppliers. It also applied the concept of creating business opportunities through small projects between SMEs and MNCs, where the objective was to help local suppliers to rise in the value chain, ultimately becoming global suppliers. The creation of CRP was not accomplished by a law. Nevertheless, its activities are influenced by the EPZ Law and its regulations, particularly with respect to customs procedures.

Despite its long history, this set of policies have obtained, at the best, mixed results. Nowadays, the program got shaped as the Export Linkages Department in PROCOMER that manages a database of 720 providers. Between the years 2001–2011, the number of backward linkages registered by CRP increased from 1 to nearly 248, representing US$0.8 million of sales in 2001 and US$9.0 million in 2011. Groote (2005) found that only 17.3 % of the linkages created by CRP were incorporated into the high-tech MNCs' final products. Thus, more linkages were related to non-specialized inputs. During the 2007–2009 period, the number of backward linkages increased significantly, from 141 in 2007 to 197 in 2008

[8] See File 7870 of the Export Processing Zones and Industrial Parks Law (Law 6695 of 1981).

and 220 in 2009. By 2011, the total amount of linkages was 248. Throughout the 2001–2011 period, the program generated 1,355 linkages between local firms and MNCs, valued at around USD 50 million. Yet this is a small figure compared with FTZ companies' expenditures (USD 1.78 billion) in Costa Rican goods and services in 2010.

5.1.3 R&D and Innovation Policies for SMEs

The idea of supporting investment in R&D of SMEs originated almost two decades ago, with the Law for the Promotion of Scientific and Technological Development (Law 7169) in 1990, which created the Ministry of Science and Technology of Costa Rica (MICIT). A decade later, in the year 2000, a new mechanism called Financing of Technological Management for Industrial Change or the Grants Fund (FRC, Fondo de Recursos Concursables) was created. Its objective was to promote R&D in SMEs (companies with less than 100 employees) and enhance management capacities and competitiveness. The FRC was developed by MICIT, CONICIT, and the Presidency (through the so-called Programa Impulso). In 2002, the FRC was modified in by Law 8262 (Law for the Strengthening of SMEs). A new fund called PROPYME (Programa de Fortalecimiento para la Innovación y Desarrollo Tecnológico de las PYMES) was established to promote entrepreneurship and competitiveness of Costa Rican SMEs, through innovation and technological development, and to contribute to economic development.

The Economic Affairs Commission of the Congress concluded that SMEs required an integrated PDP to enhance systemic competitiveness and correct several distortions resulting from obsolete infrastructure, burdensome red tape and business creation costs, wide interest rate spreads, expensive public services, and an inefficient tax system. The Commission supported Law 8262 based on a study that pointed out critical obstacles to SME growth, namely

- Limited access to market intelligence and advanced technologies
- Limited coordination among sectors
- Scarce resources for productive, R&D, and training investments
- Limited access to financing due to guarantees and other banking requirements
- Low production volumes and quality standards which impede access to international markets
- Lack of entrepreneurial capabilities and limited managerial skills
- Limited support of current PDPs for SMEs.

The Commission argued that the promotion of the SMEs required a public policy to improve systemic competitiveness. In this context, and after reviewing the WTO Agreement on Subventions and Compensatory Measures (SCM), the Commission concluded that subsidies to correct evident market failures or those situations where high shadow costs exist (government failures) were permissible.

The transformation of FRC into PROPYME was an important legal and institutional improvement. According to Law 8262, PROPYME resources come from

Costa Rica's public budget, are allocated annually by the Incentives Commission at the Ministry of Science and Technology (MICIT), and are managed by the National Council for Scientific and Technological Research (CONICIT). Such a mechanism attempts to avoid resource allocation distortions caused by political influence, corruption, or at least moral hazard and discretionary management. The fund can be used to finance the following types of projects:

- Technology development
- Innovation and patent creation
- Technology transfer
- Human capital development
- Technological services development
- A combination or complementary pool of projects.

The Ministry of Science and Technology is responsible for PROPYME policy design and implementation and is directly involved in monitoring and accountability. In addition, the Ministry of the Economy serves as a consultation body, the MEIC elaborates the general framework of this PDP, and CONICIT is responsible for monitoring and accountability issues.

Between 2003 and 2011, a total amount of 170 project proposals were submitted to the MICIT; only 143 were finally approved. From these 143 approved projects, only 114 were finally funded.[9] In short, between 2003 and 2011, PROPYME supported 114 innovation projects carried out by 87 SMEs, receiving a total amount of investment of US$1.7 million during that period, with an average amount of US$15,067 allocated to each firm. The largest number of projects proposed was related to technological development, while the largest number of projects financed was those related to human capital development. Funding for projects related to patents or technology transfers have not been requested by firms during this period. The absence of funded projects aimed at registration of patents is a clear limitation to innovation and productivity growth of Costa Rican firms.

According to Monge-González et al. (2010), the majority of managers in Costa Rican SMEs do not know about the existence of PROPYME program and are thus unable to take advantage of PROPYME financial instruments. Other companies indicate that they know about the program indirectly, because of information obtained from the Chamber of Industries. Once they learn what PROPYME does, the companies express their interest in applying and stress the importance of this kind of policy to overcome technological and human capital weaknesses. The same authors stressed that between 2003 and 2008, only 14 % of the total Propyme projects funded were undertaken by local suppliers of MNCs. Based on this result and the need for innovation improvements by local suppliers of MNCs, a cooperation agreement was signed in 2012 between the Ministry of Foreign Trade (COMEX) and the MICIT to increase the use of PROPYME resources by these local suppliers. As a result of this effort, the total amount of

[9] Some businesses abandoned the project for various reasons, most often because they were in disagreement with the research unit assigned to them for joint implementation of the project.

available resources for 2012 in PROPYME was allocated, and more than 40 of the beneficiaries are local suppliers of MNCs. This recent effort is of fundamental importance in light of an impact evaluation of PROPYME (Monge-Rodriguez and Rodriguez-Alvarez 2013) that found that PROPYME has positive and significant impacts on employment and exports of beneficiary firms, but not on the real average wages of the employees of these firms. In the first case, it may be concluded that among treated firms, labor demand is 18.5 % points higher than that among untreated firms. In the second case, it may be concluded that the exporting probability of treated firms is 3.2 times higher than that of untreated firms. These impacts are observed for up to 2 years after the firm participated for the first time in the program (in the case of exports). Likewise, it was found that the time elapsed since the first treatment, as well as the amount of times a SME participates in the program, has a positive impact on labor demand and on the probabilities of exporting of beneficiary firms.

Similarly, the need for further coordination is highlighted by the evidence on the complementarities between CR Provee and Propyme programs (Monge-Rodriguez and Rodriguez-Alvarez 2013). Firms treated simultaneously by both programs experience a greater improvement in their productivity than those which were only treated by CR Provee. Thanks to such increases in productivity, firms which are simultaneous beneficiaries of both the CR Provee and the Propyme programs are able to pay higher average wages to their employees than non-beneficiary firms. Similarly, it was found that when a CR Provee beneficiary firm is simultaneously supported by Propyme, its probability of exporting increases significantly. These results are especially interesting for policy makers because they indicate the importance of bundling in the implementation of PDPs.

MICIT is responsible for innovation priority setting, policy design, and strategy setting. Despite its complex responsibilities, MICIT has a budget of USD 12 million, of which more than 50 % is automatically transferred to science and technology institutions without any type of performance-based contract. Given the recognition of the cross-sectoral and cross-ministerial function of innovation policy, MICIT is involved in several national councils, including the PCCI. In 2010, it launched the National Plan for Science, Technology, and Innovation 2010–2014 which established sectoral priorities (Seven sectors) although has no budget indication or estimates of the resources to be allocated to each sector or the required moneys to achieve the goals listed in the Plan.

It should be noted that the national innovation strategy's sectoral priorities are not necessarily aligned with sectoral targeting for FDI attraction. While some areas do overlap (for example, the scientific area of renewable energies is close to the clean technology sector and health is linked to the life sciences industrial cluster), aligning sectoral priorities would make government action more effective, especially in creating the innovative environment at the cluster or sectoral level necessary to attract more innovation-related FDI. This low level of coordination is reflected both in the innovation policy's relatively weak support to companies and in the scant support for training and research in S&T fields (OCDE 2012).

5.2 The Presidential Council on Competitiveness and Innovation

One of the early actions of the new administration (2010–2014) was the creation of several presidential councils, among which is a Presidential Council on Competitiveness and Innovation, whose members include the President, both vice-presidents, the Ministers of the MICIT and most other major government ministries, as well as the executive presidents of major government institutions such as the National Training Institute [INA—the branch of the Ministry of Labor (MTSS) in charge of technical training], and the Costa Rican Electrical Institute (ICE), the government telecommunications and electricity provider.

The creation of this Council has for the first time provided a forum in which innovation and its economic impacts are regularly discussed by the highest government authorities. The Council is assisted by a Technical Secretariat which provides diagnostics and other information requested by Council members, and which also assists in the design of solutions in priority areas, and monitors the execution of policies, plans, and actions related to the promotion of innovation.

The recent creation of the Presidential Council on Competitiveness and Innovation now allows the MICIT to systematically coordinate its activities at a ministerial level with those of other government agencies in areas related to innovation. The Council was created to align the different policies influencing the country's competitiveness. Its creation holds promise because it generates a space for policy dialog and information sharing, but assessing it would be premature. In addition to coordinating inter-agency activities related to innovation, the Council also provides oversight for the MICIT's efforts in the promotion of science, technology, and innovation and may provide recommendations and assistance in elaborating plans and policies.

5.3 Challenges Ahead

Although the Council is relatively new to fully assess its impact, it is already possible to stress the need to endow the PCCI with more enforcement power to elaborate shared guidelines and priorities to foster policy coordination among different sectoral ministries. Although it enjoys the political support, it might be advisable to make of the PCCI a technical environment, with clear rules about the nomination of members and duties.

In fact, it should be responsible for ensuring the implementation and follow-up of decisions stemming from its discussions and deliberations. At the same time, Costa Rica would benefit from increasing the diagnostic capabilities to improve priority setting, accountability, and monitoring of outcomes. In this sense, OCDE (2012) suggests the creation of a small and agile observatory-type institution operating under the direction of the PCCI in close collaboration with the national

statistical office. This institution would be responsible for building an information system centered on production and innovation dynamics, including research centers, universities, and foreign and national companies. The observatory could contribute to investigating market dynamics, including the potential misalignment between skills demand and supply. In this sense, the creation of an inter-institutional working party for skills (led by COMEX and mostly held around the CPPI mandate) might be considered a building stone for such an endeavor.

6 Conclusions

In recent decades, Costa Rica viewed FDI attraction as a strategic option to sustain growth, promote structural change, and create better jobs. The successful record of FDI investment in the country fostered profound changes in the country's trade specialization, inducing derived demands for new and better skills in the population and wider availability of entrepreneurial and technical capabilities in specific industrial clusters. In fact, labor mobility from global to domestic firms has had a positive impact on rate of creation and survival of knowledge-intensive firms in the country. However, the linkages between local and foreign companies in Costa Rica are still weak, and R&D and innovation investments are coming short for the country needs. In this scenario, Costa Rica, joining an emerging world trend, has been shifting gradually toward a more selective policy approach to FDI by targeting certain knowledge-intensive sectors, while some global firms have recently moved toward more sophisticated activities in the country.

Aiming particularly at attracting knowledge-intensive FDI requires improving the governance and policy mix for FDI attraction and to combine it with other realms of policy (i.e., education, training and skill provision and science, technology, and innovation, specifically). In fact, and of particular relevance for countries like Costa Rica that have put a visible emphasis on FDI disregarding—to some extent—the development of domestic SMEs, this framework requires to strengthen the "innovation climate," generating a pool of available resources to be tap in the form of supplier–buyer relations.

Obviously, the success of this new endeavor will depend on the coordination and the capacity to "activate" (OCDE 2012) government policies beyond investment promotion, per se. The successful experiences throughout the world show that knowledge-intensive FDI is more sensitive to the availability of skills and research capabilities (including R&D laboratories, innovation platforms, and clusters of companies and research institutions) that foster an innovative environment. Good practices in this field call for higher levels of integration and coordination among FDI promotion policies and key complementary policies in the areas of innovation, education, and industry.

Public institutions like CINDE have earned a reputation for their success in attracting high-tech FDI and coordination capabilities across the public sector and timely response to specific private demands. Similarly, the more recent creation

of the PCCI in 2010 aims at improving the governance of this new approach to development, through the coordination of the needed policies.

In this setting, it becomes of the most importance that the PCCI to be responsible for ensuring the implementation and follow-up of decisions stemming from its discussions and deliberations, while strengthens its diagnostic capabilities to improve priority setting, accountability, and monitoring of outcomes. Probably, the probe of this effort should be the implementation of ambitious program for the development of advanced human skills that breaks the misalignment between demand and supply. The Working Party on Human Capital (Foro de Capital Humano) requires being at the center of the stage of this new development policy. More demanding activities and functions by both global and domestic firms will certainly follow the good results in this matter.

References

Agosín M et al (2009) Costa Rica, Diagnóstico de Crecimiento. IDB/CID, Washington DC

Consejo Nacional de Rectores (2011) Cifras Relevantes de Educación Superior de Costa Rica

Consejo Nacional de Rectores (2012) Seguimiento de la condición laboral de las personas graduadas 2000–2007

Crespi G (2010) Nota Técnica sobre el Sistema de Innovación en Costa Rica. IDB Technical Note. IDB, Washington DC

Crespi G et al (2012) ¿Es la inversión en innovación una inversión menos rentable? Evidencia para América Latina. In: Rojas K (ed) Inversión en ciencia, tecnología e innovación. Proyectando a Costa Rica. Editorial Académica Española, Saarbrucken, p 18–26

Groote R (2005) Costa Rica. Proyecto de Desarrollo de Proveedores para Empresas Multinacionales de Alta Tecnología. ATN/ME-6751-CR. Final evaluation

Inter-American Development Bank (IDB) (2010), The Age of Productivity. Transforming Economies from the Bottom Up, Palgrave Macmillan, March 2010

Melo A, Rodríguez-Clare A (2006) Productive Development Policies and Supporting Institutions in Latin America and the Caribbean. IDB Research Department Competitiveness Studies Series. Working Paper C106. IDB

Ministerio de Ciencia y Tecnología (MICIT), Consulta Nacional de Indicadores de Ciencia, Tecnología e Innovación 2008–2012

Ministerio de Ciencia y Tecnología (MICIT) 2009, Encuesta Nacional de Innovación

Monge-Ariño F (2011) Costa Rica: Trade Opening, FDI Attraction and Global Production Sharing. Economic Research and Statistics Division, Staff Working Paper ERSD-2011–09. WTO

Monge-González R, González C (2007) The role and impact of MNCS in Costa Rica on skills development and training: The case of Intel, Microsoft and Cisco. ILO, Geneva

Monge-González R, Hewitt J (2008) Innovation, Competitiveness and Growth: Performance in Costa Rica and its ICT Sector. Costa Rica Digital 5

Monge-González R, Rodríguez Álvarez JA (2012) Impact Evaluation of Innovation and Linkage Development Programs in Costa Rica: the cases of Propyme and CR Provee. IDB

Monge-González R, Rodríguez Álvarez JA (2013) Impact Evaluation of Innovation and Linkage Development Programs in Costa Rica: the cases of Propyme and CR Provee. IDB

Monge-González R et al (2010) Productive Development Policies in Costa Rica: Market Failures, Government Failures and Policy Outcomes. IDB Working Paper Series 157. IDB, Washington DC

Monge-González R et al (2011) Impacto de los derrames de conocimiento desde las multinacionales en las empresas locales de Costa Rica. IDB/Academia de Ciencias de Centroamérica

OECD (2012) Attracting Knowledge-Intensive FDI to Costa Rica: Challenges and Policy Options. OECD Development Centre, Making Development Happen. OECD, Paris

Paus, Eva and Gallagher, Kevin (2008) 'Missing Links: Foreign Investment and Industrial Development in Costa Rica and Mexico', Studies in Comparative International Development 42 (4): 53–80

Saggi K (2002) Trade, Foreign Direct Investment and International Technology Transfer: A Survey. World Bank Res Obser 17(2):191–235

Smeets, R. (2008), Collecting the pieces of the FDI knowledge spillovers puzzle,World Bank Research Observer (23): 107–138

Trejos A et al (2012) Desarrollo del talento humano: La clave para competir en la atracción de la inversión extranjera directa. INCAE

Design and Evaluation of Fiscal Incentives for Business Innovation in Latin America: Lessons Learned After 20 years of Experimentation

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Abstract This chapter presents the most important recent trends with regard to the design and evaluation of fiscal incentives for the support of business innovation in LAC. Several countries in the region have been experimenting with these policies since early 1990s, in many of these cases with technical and financial support from the Inter-American Development Bank. In contrast with the OECD countries, the LAC's business innovation support framework is clearly biased toward direct transfers to the private sector. Just a few countries have more recently started to experiment with tax incentives. However, in comparison with the international best practices, the fiscal budgets allocated to these programs are rather meager. To some extent, business innovation policy in the region is still in its infancy. Despite this, many of these pilot programs have already been assessed and this chapter takes advantage of the existent wealth of studies in order to provide a qualitative meta-analysis of the most pioneer programs in operation since early 1990s. They main conclusions are rather straightforward: There is clear evidence of a positive impact on investments (input additionality). In other words, fiscal incentives have been effective at the moment of increasing firms' investment in innovative projects and not only that they have been also effective in leveraging private resources for this investment. However, the studies also found that different financing mechanisms have varying impacts on different group of beneficiaries. Although it seems that the risks of crowding-out private investments are lower in the case of programs based on subsidized loans or tax incentives, matching grants seems to be more effective in the case of new innovators or at the

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moment of fostering linkages between firms and universities. An important policy recommendation from the different studies is that matching grants programs are a very powerful tool, which impacts might be maximized when they focus in these activities. With regard to output additionality, impacts also seem to be positive whenever enough time has elapsed since the support was approved. Indeed, the different studies that looked at output additionality suggests that positive impacts in labor productivity might be significant—in the range between 5 and 25 %—but that results start to show up only after three to five since the start of an innovation project. The chapter also indicates that the main considerations of design should be taken into consideration at the moment of increasing the efficiency of these programs and at the same time minimizing problems of moral hazard.

1 Introduction

Since the beginning of the 1990s, several Latin American countries have witnessed a systematic growth of public programs aimed at enhancing firm-level innovation and technological upgrading. The overarching justification for these programs is that the market has failed to provide the incentives needed to reach an optimal level of private investment in innovation activities.[1] Therefore, Latin American firms have failed to adopt modern technologies and business practices that would have helped them to improve their productivity and competitiveness.

In this context, several Latin American countries have introduced various types of fiscal incentives to stimulate innovation activities and to strengthen the linkages among firms and other agents in the National Innovation System (NIS).[2] The first of these fiscal incentives program was started in Chile in 1991 and since then they have spread throughout the region in the extent that nowadays about 70 % of the countries in LAC have put in place some form of fiscal incentive program for innovation.

Almost 20 years have already elapsed since then and pari passu with the experience accumulated with the actual implementation of these policies, a systematic amount of evidence and methodological learning has been produced

[1] Investments in innovation activities include both tangible (machinery and equipment, computer hardware, etc.) and intangible components (research and development, design, software development, etc.).

[2] Metcalfe (1995) states that NIS is "that set of institutions that jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store, and transfer the knowledge, skills, and artifacts, which define new technologies. The element of nationality follows not only from the domain of innovation policy but also from elements of shared language and culture that bind the system together and form the national focus of other policies, laws, and regulations that condition the innovative environment."

with regard to the effectiveness of these incentives to alleviate the different market failures that hinder innovation and productivity in the region. The aim of this paper is to carry out a qualitative "meta-analysis" of these programs (and their respective impact evaluations) in order to take stock of the learning achieved so far and provide specific recommendations of how public policy should be better designed in order to maximize additionality and productivity impacts.

This chapter is structured around the following sections. Section 2, after this introduction, provides the context of this chapter by presenting a short overview of the regional innovation performance over the last 20 years. Section 3 summarizes the different rationales that justify public policy intervention with regard to business innovation. Section 4 presents the landscape of different policies interventions in the region and describes their main characteristics with regard to how they have actually been implemented. Section 5 presents a "meta-analysis" by making a comparative analysis of the most recent evaluations done so far. Section 6 concludes with a summary of the emerging issues with regard to the design of future innovation policies.

2 Innovation at a Glance: The Regional Landscape

On average, Latin American and Caribbean countries underperform other developed and developing countries in terms of productivity growth. This poor productivity outcome explains why the region has shown very modest economic growth in the last 30 years and why, despite unusually favorable international conditions over the last half decade, the region still lags behind other regions in terms of economic growth. Indeed, the top left panel of Fig. 1 shows the evolution of the productivity gap between the typical LAC country and the USA. Taking into consideration that the productivity gap has been normalized to one in 1960, the figure clearly indicates an increase in this gap since then. In other words, the productivity gap of the region with regard to the USA—which is normally taken as the proxy for the best practice frontier—is today about 60 % higher of what it was in 1960 (IDB 2010a). This situation is pretty unique to the LAC region, as other regions in the world have managed either to keep track with the best practice frontier or to catch up with it.

Innovation broadly defined as the introduction of new products or processes by firms has been credited as the ultimate engine of productivity growth by a vast amount of economic literature.[3] The entrepreneurs, motivated by profit, look for better—meaning more efficient—ways of doing things that can be commercially viable, and in the process they come up with new routines, production arrangements, materials, or machinery that saves costs and/or improves output's quality.

[3] The OECD defines innovation as "new products, business processes and organizational changes that create wealth or social welfare" OECD (2005).

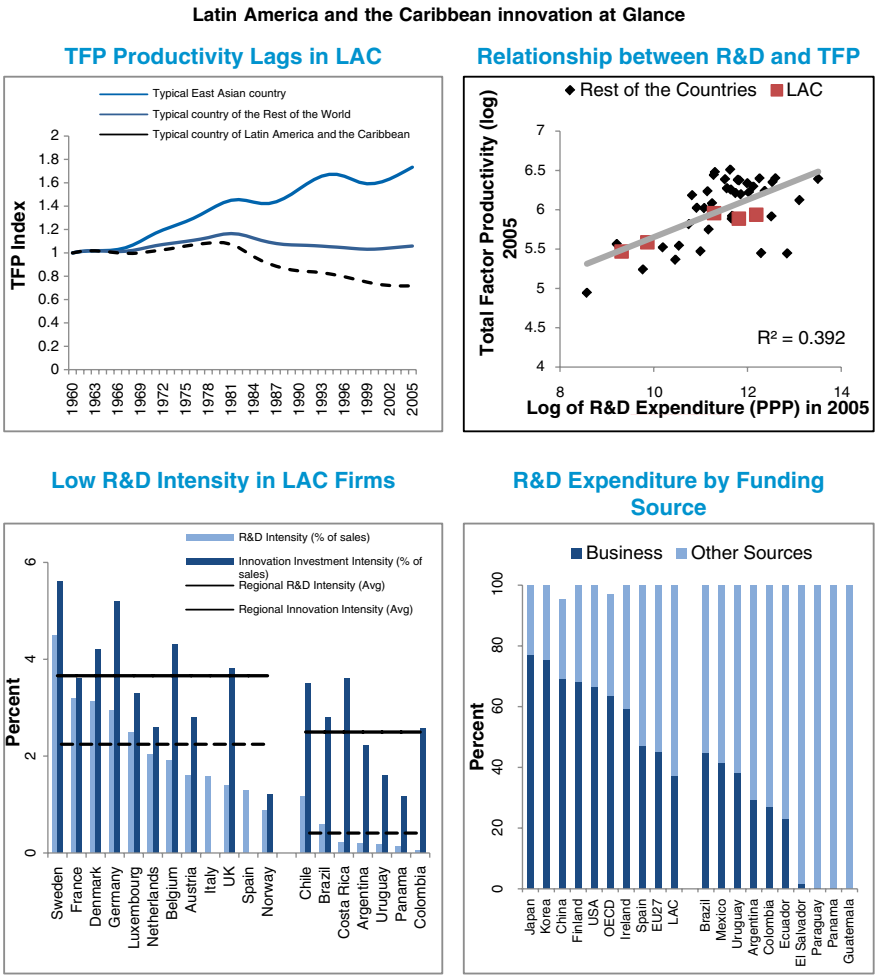

Fig. 1 Latin America and the Caribbean innovation at Glance. *Source* IDB (2010b)

In fact, the top right panel of the Fig. 1 shows that there is a positive and statistically significant correlation between productivity and investments in R&D across a large cross section of countries, the strength of this correlation suggests an investment with high social return rates, and indeed, about 40 % of the variations in productivity in the sample are due to variations in investments in R&D.

Yet it is also a well-established fact that firms in Latin America register what appear to be sub-optimal levels of investment in innovation (both the tangible and intangible components). Certainly, the bottom left panel of Fig. 1 compares the business innovation investment rates across a sample of OECD and LAC countries where information is available and internationally comparable. The figure also shows the average investment rate for these two regions, suggesting two clear

findings: (1) average innovation investment rates are clearly lower in LAC than in OECD countries and (2) that the investment gap among these two regions is particularly severe in the case of the intangible component of that investment—which is R&D.[4]

Figures available at the macro-level indicate not only that the general level of expenditure in innovation is low by international standards, but also, notoriously, that most of the innovation investment in the region (about two-thirds of it) is directly performed by the public sector (see the bottom right of Fig. 1). This is in stark contrast with OECD and successful catching-up economies, where about two-thirds of innovation investments come from private sources. This is also confirmed by micro-evidence that suggest that, more often than not, innovation is not a preferred path for many Latin American firms, in their search for profitability, the opening of new markets or the consolidation of advantages relative to competitors (IDB 2010b). Such a weak propensity to engage in innovation activities by the private sector is all the more noteworthy given that studies that have looked closely at the profitability of innovation in Latin American firms show consistently positive returns (Crespi and Zuniga 2011). Such a reluctance of the private sector to invest in innovation has been traced to a set of ailments that hinder the private returns of these investments at the firm level.

3 The Rationale for Innovation Policies

The fundamental premise for innovation policies is that government intervention would be necessary if profit-driven actors underperform with regard to the production and/or exchange of technological knowledge from a social welfare perspective (Steinmuller 2010). The economics of innovation literature has provided several rationales as to justify that indeed this is the case. Broadly speaking, the rationale for public policy in this field can be articulated around the following considerations:

1. *Spillovers and the "public good" nature of knowledge*.

Since the seminal works by Nelson (1959) and Arrow (1962), scientific and technological knowledge has been regarded as a non-excludable and non-rival good. In the extent that private benefits associated with knowledge creation are not fully appropriable by the innovators, this creates a wedge between the private and social returns of knowledge investments, leading to a rate of investment in knowledge

[4] Although it is true that R&D investments are normally more oriented to the introduction of innovations with a high level of novelty—in other words, they are targeted to innovations that push the technological frontier—there is also an important consensus in the literature that a minimum level of R&D is also necessary in order to create enough absorptive capacities as to search for, adopt, and adapt already existent technologies to the local contexts. The concern is that not even this minimum level is reached in the region.

that will fall short from socially optimum levels. This rationale applies not only to the *levels* of innovation efforts but also to the *direction* of these efforts. Certainly, the "public good" rationale of knowledge applies more strongly in the case of *scientific* rather than *technological* knowledge.[5] In the extent that the latter is more applied, predictable and linked to firm specific assets, it is more likely that innovators will be able to collect a larger share of the value of innovation to society, and so that private sector investments in technological knowledge would be closer—though not equal—to the optimum social levels.[6]

2. *The problem of asymmetric information.*

The economics of information literature (Stiglitz and Weiss (1981) makes clear that asymmetric information in market transactions (due to the problems of adverse selection and moral hazard) can affect firm innovation from two different perspectives. From the perspective of investment theory, innovation projects have several peculiar characteristics, which differentiate it from ordinary investment (Hall and Lerner 2010). *First*, innovation projects are riskier than physical investment projects. Consequently, external investors might require a higher risk premium for the financing of innovation activities. *Second*, because of the problem of spillovers, innovators are themselves reluctant to share information about their projects with potential outside investors furthering worsening the asymmetric information problem. *Third*, the difficulty of using intangible assets as collaterals also leads to increased costs of external capital in the form of a higher risk premium. In summary, asymmetric information would lead to a wedge between the opportunity cost that private innovators require to their innovation investments and the capital cost that external investors are willing to charge to finance innovation projects, the result will be that privately (and eventually socially) profitable innovation projects will not materialize due to the fact that financing costs are simply too high.

The second perspective on how asymmetric information affects innovation concerns to knowledge dissemination and it relates to the fact that private actors do not have "perfect information" on technology or production possibilities. In the same way, adverse selection and moral hazard problems also extend to the (imperfect) operation of technology markets. This claim is consistent with two empirical findings: (1) that there exist persistent differences in the technological performance between countries and so that catching-up is very far from being an automatic process consistent with the idea of knowledge as a global public good

[5] On the other hand, projects with a significant component of basic research are unlikely to produce results with commercial application in the short run. Although this may discourage private investments, the projects could still have a high social return because of the skills and knowledge produced during their development, apart from their final achievements.

[6] The applied nature of technological knowledge also made it more likely of being protected by intellectual property rights. However, this by no means implies that firm investment in technological knowledge will be socially optimum, appropriability problems also exists in the case of this knowledge as the coverage offered by intellectual property rights protection is usually limited.

(Fabegerber and Verspagen 2002) and (2) that the process of technology diffusion, even within narrowly defined industries, is very sluggish leading to a persistent firm heterogeneity in productive performance (Disney et al. 2003).

3. *The pervasiveness of coordination and institutional failures.*

A key contribution of the innovation systems literature is that knowledge has non-negligible tacit components and as such innovation is the result of feedback and interaction involving numerous actors (Lundvall 1992). Although many of these interactions are market mediated, a large proportion of them are governed by non-market institutions. *Because the efficiency of this process at the macro-level depends on the behavior of individual actors and the institutions that govern their interaction, coordination problems might arise* (Soete et al. 2010). A nice example where these coordination problems could emerge refers to the setting of standards that regulate producer–user interactions in the case of General Purpose Technologies (GPTs). GPTs are a set of technologies that spread out across different economic activities leading them to innovate as well. Progress in the adopting sectors feeds back into GPTs developers, generating a process of sustainable growth (Bresnahan and Trajtenberg 1995; Aghion et al. 2009). It is also clear that the way about how these technologies contribute to growth is not only through the development of GPTs intensive sectors per se (the supply side) but also, and even more critically, through the development of the *complementary* innovations that facilitate their wider adoption across the *other* sectors of the economy, which start to innovate as a consequence of this. This requires the solution of coordination problems. The solving of the coordination problem requires not only putting attention to the linkages among the actors but also to their absorptive capacities (Cohen and Levinthal 1989). The concept of absorptive capacities is a key ingredient of the new literature of innovation, in particular from the perspective of catching-up economies. Following Steinmueller (2010), the concept of absorptive capacities refers to fact that new knowledge might not be employable without heavy co-investments by the users in corresponding human capital and learning; furthermore, it also implies that the new knowledge might not be reproducible without the direct assistance of the originator.

In the extent that human interactions are governed by institutions, the innovation systems literature puts a strong emphasis on institutional governance and change. These refer to institutional design arrangements that foster public–private interactions and at the same time minimize problems of moral hazard. Institutional change interventions refer also to arrangements that build linkages between the different actors involved in the innovation process (such as universities, public research organizations, technology producers and users, and consumers) either by defining new roles to already existent institutions (such as allowing the patenting of university research in order to encourage technology transfer) or by creating clubs or consortiums that regulate interactions between the agents (Steinmueller 2010). These sorts of arrangements may lead to a better equilibrium either because innovation costs are not duplicated in separate efforts that lead to identical results or several externalities are internalized. In this case, public intervention is often

required to reduce the transaction costs that may hamper the formation of the joint venture and to regulate their activities in order to achieve the desired balance between cooperation and competition.[7]

4 The Implementation of Innovation Policies in LAC

The previous analysis offers different conceptual frameworks that justify the implementation of innovation policies based on the idea that profit-seeking agents will produce both a level and direction of knowledge investments, which will fall short from socially desirable outcomes. Following David et al. (2000), broadly speaking public policy has suggested two main approaches in order to solve the under provision of innovation efforts by private firms: (1) direct production of knowledge in public institutions (laboratories and public research institutes) and (2) fiscal incentives for a greater amount of private investment in knowledge generation. Without ignoring the importance of government investments in public research organizations, the issues related to the governance, funding incentives, and productivity impacts related to the operations of these organizations are enough complex as to require a far more specific focus than the scope of this chapter. Regardless to this, in this chapter, we will specifically focus on the second class of policy designs, in particular given their growing importance in the LAC region. In particular, we will focus on two particular classes of fiscal incentives: direct subsidies and tax incentives, without ignoring that other types of incentive designs are also available (such as adoption subsidies, technology acquisition policy, signaling strategies, information diffusion policies, thematic funding, and entrepreneurship programs); however, the empirical evidence and learning accumulation on the impacts of these other designs in the region is far more limited.[8]

Both direct subsidies and tax incentive schemes have been in place in the LAC region since early 1990s and more countries seem to be eager to adopt them. Figure 2 summarizes the degree of penetration of fiscal incentives for innovation in LAC, and it compares it against the OECD countries. In the OECD, almost 80 % of the countries have implemented a matching grants system and 66 % have also implemented a tax incentive, with 45 % of the countries having both of them. The degree of penetration is somehow lower in LAC. Indeed, only 65 % of the countries have put in place a matching grants mechanism and just about 30 % have tax incentives. Moreover, just 30 % of the countries have both systems in place, while 35 % have none of them. On the other hand, in the OECD there is no country without some sort of fiscal incentive for business innovation.

[7] The regulation may allow and encourage firms to coordinate their R&D investment during the first stage of a project (e.g., the basic research stage) and then force them to engage in Cournot or Bertrand-type competition in the second stage (e.g., prototype development). On this topic, see among others Martin and Scott (2000).

[8] For some references, see Steinmueller (2010) and IDB (2010a).

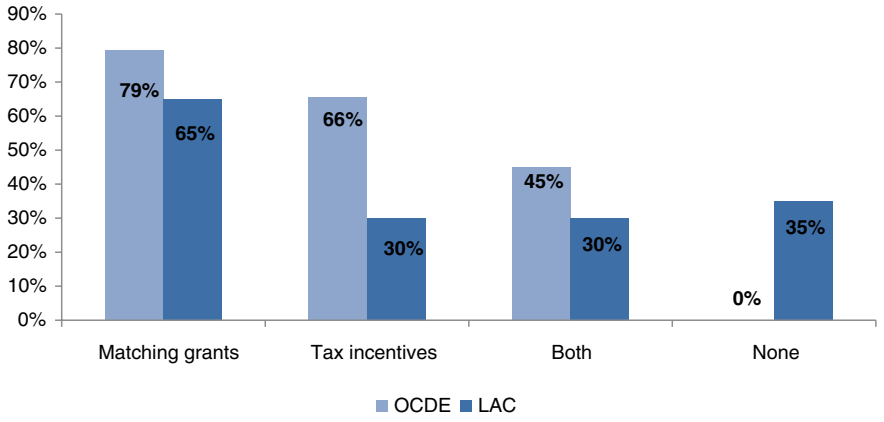

Fig. 2 Percentage of countries with fiscal incentives for business innovation. *Notes* Own elaboration using UNESCO and IDB database "Politicas e Instrumentos en Ciencia, Tecnologia e Innovacion en America Latina y el Caribe" and Table 7 of chapter Evolution of the Public Institutions of Science, Technology and Innovation in Chile: 1990–2012 of "OECD Science, Technology and Industry Outlook 2010." OECD refers to 29 countries that outside LAC present either full members or in open discussions for accession. The list includes Australia, Austria, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Japan, Korea, Netherlands, New Zealand, Norway, Poland, Portugal, Russian Federation, Slovenia, South Africa, Spain, Sweden, Turkey, the UK, and the USA. In the case of OCDE, matching grants comprises R&D subsidies and competitive grants schemes. LAC comprises Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Guatemala, Honduras, Jamaica, Mexico, Nicaragua, Panama, Peru, Paraguay, Salvador, Trinidad and Tobago, Uruguay, and Venezuela

From a practical point of view, it is worth to emphasize the main differences between the direct subsidies and tax incentives and also their main pros and cons with regard to implementation:

1. **Direct Subsidies**: Subsidies are a type of *direct support* for business innovation which is *project-specific based*. So, they modify the firms' marginal cost of capital and may raise the private marginal rate of return of the innovation investment by, for example, inducing collaboration with other actors with complementary assets. Because they are project based, subsidies allow public agencies to target projects with perceived high marginal social rates of return. Given the problem of asymmetric information between the public agency and the beneficiary, direct subsidies might suffer from opportunistic behavior and moral hazard problems. Indeed, while the public agency might want to maximize firm's innovation efforts, private entities might aim at maximizing the size of the innovation project (and of the subsidy). However, although not fully eliminated, the moral hazard problem implicit in a direct subsidy could be controlled for by a design that considers the two following key attributes:

   (a) Subsidies are normally allocated under a *matching grant* approach with *maximum* limits and list of eligible expenses; in other words, the subsidy

never covers the full costs of the supported project.[9] It is expected that using this approach there will be a better alignment between the goals of the public agency and the firm, somehow controlling for the potential problem of moral hazard. In order words, if the beneficiary wants to increase the size of the innovation project in order to extract a higher subsidy, it will have to pay also a higher cost. Related to this, a nice feature of this cost-shared approach is that public agencies can also adjust the amount of the co-funding according to the main characteristics of the projects or the beneficiary. Indeed, in the case of innovation projects, the share of the subsidy might increase when the project implies the participation of more than one beneficiary due that is expected that projects that involved more than one firm or a firm collaborating with a university might lead to higher spillovers. Sometimes subsidies might target the fixed capital component of an innovation project (for example, the R&D laboratory or the CAD system) under the assumption that when these capabilities are available they might reduce the innovation costs of future innovation projects. Alternatively, there might be an increase in the subsidy component when the project's beneficiary is a small firm under the assumption that the intensity of market failures faced by SMEs is also higher.[10] Finally, the operation of the co-funding mechanisms is normally implemented through the ex-post reimbursement of the approved expenditures that qualify for the subsidy.

(b) Subsidies are also normally allocated using a competitive *call for proposal process*. The competitive process allows the public agency to identify the best proposals (selection based on merit) and to allocate the resources among them according to some evaluation score normally set by external evaluators or peer-reviewers. In some cases, on the top of a technical evaluation, a social cost-benefit evaluation might be carried out in order to identify the economic relevance of the project. In order to allocate the subsidies the public agencies normally put in place an adjudicatory commission formed with representatives from government, private, academic, and civil society organizations, increasing transparency and reducing the risks of capture.

However, the above-mentioned counter balances come to some costs. The main problem with the direct subsidy schemes is that they need important institutional capacities in the executing agency and when these capacities are not present the

[9] Although there are important variations in the sorts of expenditures that are eligible for the subsidy, the typical matching grant program normally pays for research variable costs (researchers' salaries, research inputs and the costs of outsourced R+D); however, in some cases, a fraction of the fixed costs of laboratory and testing equipment is also included. Some programs also include among eligible costs those expenses related with either the acquisition of intellectual property rights such as the purchase of a license or patent/trademarks application costs.

[10] Co-funding normally varies between 20 and 70 % of the overall project costs.

efficiency of the whole operation dramatically decreases. The building of these capabilities requires that two additional conditions need to be met: First, the system needs to be quite predictable in order to allow for policy experimentation, monitoring, and evaluation to take root and second that some critical mass of human capital in the executing agency and the support system is available (evaluators, peer-reviewers, etc.).[11] On the top of this, additional costs of administrating grants disbursements also should include compliance with the often-complex regulation of public fund disbursements (Steinmueller 2010). For this reason, implementation has been normally done by either newly created specialized institutions (such as innovation agencies) or by augmenting the scope of already existent institutions (such as national research councils).

A second problem with the matching grants is that, as subsidies are paid ex-post against receipts, they do not seem to be very suitable for the promotion of entrepreneurship. Indeed, if it is the case that the (new) entrepreneur is credit constrained, this type of funding may be of little help. Some designs are trying to correct for this through the inclusion of partial advanced funding provisions for new firms, but even in this case this advanced cash needs to be covered with guarantees.[12] A third problem with the matching grants approach relates to the competition process, unless several competitions are open during the year, companies might have to wait for several months until they can apply for funding, this could make the scheme less interesting in particular for firms where the market lead is a key competitive assets.[13] Finally, a fourth a key issue, when direct subsidy schemes are implemented in weaker context is that their success depends on firm's ability to identify an innovation opportunity that can be codified into a coherent project proposal. The presence of these sorts of capabilities on the demand side of the scheme is not something that can be taken for granted. Some schemes in the region are trying to mitigate for this problem by complementing the scheme with the support of small grants for project formulation or through the establishment of two-step competitions (a call for concept notes and then a call for full proposals).

[11] When these capacities are not met, the outcome might be high administration costs. This is very clear at the early stages of policy experimentation when it is not uncommon to find that hurdles to apply are high, the speed at which applications are processed are too slow and the opportunity costs of applying forbidding in particular in the case of SMEs and start-up firms.

[12] An important caveat here is that as soon as public agencies act as a screener, conveying the technical knowledge that the financial markets lack or are willing to develop, they should also reduce the usual asymmetry of information problem between the financial sector and the innovative firms. By this way, and in some extent, granted subsidies based on externally and technically evaluated projects might "signal" a good innovation idea that might later on be funded by the financial markets (more on this in the next section).

[13] In order to relax this constraint some agencies also operate an "open window system" where firms could apply at any time. In this case, project proposals are still evaluated from a technical point of view and, sometimes, from a cost-benefit point a view; and also the project, if it passes the cut-off score still needs to go to the adjudication board for approval. The main difference with the call for proposals system is that in this case competition is weaker as firms that file their proposals earlier are more likely to be funded.

The direct subsidies programs in the region have also followed a clear evolution over time. Since a pure horizontal approach, they have gradually moved toward a more targeted approach focused on particular sectors or technologies. There are two main rationales for this (1) to avoid dispersion of the limited resources available for innovation support and so the need for reaching some sort of critical mass to have impact and (2) that the policy learning achieved during the horizontal phase might have allowed the policy markets to learn about main market failures and other constraints that firms face in order to innovate, leading them to the development of more tailored made innovation policies.

Another interesting evolution has been with regard to the coexistence of matching grants with subsidized or conditional loan program lines. At the beginning of the 1990s, several countries experimented with these sorts of loans. In this approach, loans could be partially or even totally forgiven on the basis of three criteria: the success or the failure of the project, the nature of the beneficiary, and the level of project technological risk. However, the coexistence of the loans with similarly oriented matching grants program lines led to competition between both interventions and a very little interest by the firms on the conditional loans. So, over time the conditional loans schemes were phased out, and the overall system of direct transfers was simplified.

More recently, there has been a re-emergence of subsidized loans in some countries, now with a more clear focus on funding the adoption of innovative technologies by the firms (in particular technologies embodied in machinery and equipment). However, it is important to take into consideration that the rationale for this is in some extent different from that normally used for the support of investments in intangible assets such as R&D or design. In the case of the adoption of embodied technology, the subsidy is normally based on the potential spillovers that this technology generates to the rest of the sector or the economy, so it is an asymmetric information problem what is being targeted, once this demonstration effect is operation, the subsidy should stop. Obviously, actual implementation of the scheme requires a severe fine tuning by the implementing agency on what it should or it should not be considered an innovative technology. Despite these problems, a nice feature of the subsidized loans is that in the extent that the subsidy is small and it does not reduce the capital cost below the opportunity costs of the firm's internal funding, it becomes a very powerful tool for self-selecting potential innovators that do face liquidity constraints rather than plain rent-seekers.

2. **Tax Incentives**: Different for the direct subsidies, tax incentives are based on *firm-level* innovation activities rather than projects, so allowing the firms to get support for their whole portfolio of innovation activities without having to submit a project proposal for each one of them, this reduces dramatically firms' compliance costs and agency's administration costs. Strictly speaking, tax incentives operate through different approaches: tax credits, enhanced allowances, and accelerated depreciation of intangible investments. Tax credits allow for a direct deduction from the payable tax, while enhanced allowances and accelerated depreciation represent a deduction (above the normal

deduction rate of 100 %) from the taxable income of the company. The main difference between the two mechanisms is that the former directly reduces the tax liability, while in the latter the reduction in the tax liability depends on the effective tax rates.

In developed countries, tax incentives normally applies to the corporate income tax; however, some, in particular, developing countries have also experimented with other variations such as reductions in tariffs for imported research machinery and equipment, deductions in the value added tax and discounts in the social security and employers' contributions on the payroll of researchers' salaries. Similar to the case of the direct subsidies, the actual implementation of tax incentives requires giving some particular consideration to the following design issues: (1) the definition of a target group (the tax incentives can be made available to all firms or the support can be made more generous for SMEs or some specific sectors), (2) the regulatory labeling of the innovation activities (countries normally applies some variations of international standards following the OECD's Frascati and Oslo Manuals), and (3) the qualification of those activities eligible for the tax incentive (these might be salaries of R&D personnel, R&D expenditures—salaries plus research inputs costs—and capital R&D expenditures). On top of this, a decision needs to be made on whether the scheme will be based on the volume (deductions based on the total amount of previous qualified expenditures) or increment of the investment (based on the growth of qualified expenditures, in which case it is necessary to define the base amount upon which the growth will be calculated) (Van Pottelsberghe et al. 2009). Although the fiscal costs of increment-based tax incentives are normally much lower, they are also far more difficult to implement and monitor.

As in the case of the direct subsidies, tax incentives are also subject to the similar problems of moral hazard in the extent that firms might claim activities that they would otherwise conduct or have been conducting as innovation expenditures.[14] Averting this hazard requires the establishment of nominal limits, an auditable definition of innovation activity and active enforcement by both the innovation agency and the tax authority. So, in principle, the higher administration and compliance costs of the direct subsidies need to be compared with the higher policing costs of the tax incentive.

However, when analyzing a tax credit system several caveats need to be considered. *First*, the actual impact of the tax incentives on the marginal cost of capital of innovation activities depends on the general fiscal environment of the economy as fiscal incentives are less effective in a country with low taxes. In fact, this is one of the main reasons on why the empirical literature has normally found that tax incentives are less effective as a stimulus for innovation in SMES rather than in

[14] Tax incentives normally end up making the tax system more complex leading toward a higher degree of uncertainty with regard to the interpretation of legal regulation, requiring more auditing resources from the administration authority and to greater opportunities to manipulate the tax system generating more room for evasion and avoidance (De Luis 2010).

large companies (Harris et al. 2009). SMEs simplified tax treatments normally imply that corporate tax rates are lower in the case of this group of firms.[15] *Second*, the impact of the scheme also strongly depends on the tax position of the firm and on its ability to make profits; this does not seem to be the case for start-up firms that have just entered the market, so a priory, the power of this policy tool to promote entrepreneurship is limited. This limitation can be in some extent ameliorated through the inclusion in the scheme of carry-over provisions that allow unused portions of the credit to be carried forward to the next fiscal years. In some developed countries with, even more generous schemes, carry-forward provisions are combined with direct cash refunds, in which case the tax incentives become a grant (these are the cases in France and the Netherlands for example) (Criscuolo 2009). *Third*, and most importantly, under a tax incentive scheme is the firm who choose those innovation projects that will be implemented, so in some extent it is a mechanism that is more market-friendly than the direct subsidy and this rests under the assumption that normally the firms should have better information about what project should be pursued. An important contradiction with this rationale is that in a world with market failures, market-friendly mechanisms might not be the best channels as to guide resource allocation. In other words, giving complete freedom to the firm to choose does not guarantee that the selected projects will be also those with higher *social* return rates or those with a higher risk. So, at the end additionality could be lower as funded projects could be similar to those that would be funded by the firm anyway. Some countries have tried mitigating this problem through the introduction of differentiation with regard to the type of expense that is eligible for the tax incentive. For example, some designs increase the rate of the tax credit for in the innovation activities outsourced to universities or implemented in collaboration with other firms.

From an evaluation point of view, tax incentives also pose important challenges in comparison with the direct support. In first place, for the purpose of policy assessment, firms cannot be legally excluded from a tax incentive to which they are entitled. This removes the possibility of evaluating tax credits by constructing a control group using randomization techniques. Even the implementation of quasi-experimental techniques might be difficult when all the qualifying firms (firms that do R&D for example) receive the incentive. For this reason, one of the favorite approaches for the impact evaluation of R&D tax credits schemes resides in the utilization of structural modeling techniques (Hall and Van Reenen 2001; OECD 2010), which makes the evaluation results even more dependent on critical assumptions on firm behavior, preferences, and production technology, but that could be weaker to solve the attribution problem.

[15] However, this needs to be balanced against the fact that the final impact of the tax incentive on capital costs depends also on how the investment is going to financed. If financing is done with debt, some schemes—in particular in Latin American—allow for the deduction of interest paid for this, de facto reducing the firm's taxable base. Because large and established firms are more likely to get external financing, so this rebalance the expected impact of the tax incentive toward SMEs and new firms (if they actually make profits) (Roca 2010).

Finally, it is important to emphasize that although both types of fiscal incentives have "gross" fiscal costs in terms of either cash transfers or forgone revenues, the final "net" fiscal costs will depend on the effectiveness with which each instrument is able of increasing firm investment on innovation, on how efficient in terms of productivity this investment is and on how much tax revenues would be generated as a result of this productivity increase. With regard to the fiscal costs, a nice feature of the direct subsidies is that this cost can be incorporated into the budget process with high certainty. This might not be the case for tax incentives, as soon as the actual amount of forgone revenues could also depend on a series of endogenous decisions taken by the firms with regard to how to finance this investment or through the setting of price transfers between related companies. Moreover, in the extent that carry-forward provisions exist, incentives by the administrating agencies are toward being comparative more relaxed with regard to the approvals in the extent that the fiscal costs will be absorbed by the future administrations.[16] Although there are few studies regard to the "net" fiscal costs of innovation (mainly R&D) tax incentives, the results for developed countries suggests that the "net" costs is actual negative—or in other words that the fiscal authority recovers the costs through higher revenues (Griffith et al. 2001). However, recent evidence also shows that this might not be the case for least developed regions (Harris et al. 2009).

As it was mentioned above, several LAC countries have established innovation tax incentives during the last 15 years (Argentina, Colombia, Brazil, Mexico—recently discontinued—and more recently Chile and Uruguay). The typical LAC tax incentive presents some important differences with regard to the standard approach in developed countries. Given their importance, sometimes indirect taxes are also included among the deductions (such as the value added tax or import tariffs). But even more important is that the implementation of the scheme is mostly project based. That is in order to qualify for the tax incentive, firms are normally asked to submit a project proposal to the public agency that will review whether the project qualifies as an innovation project and it will recommend the approval of the eligible expenditures to the tax authorities who will issue a tax credit certificate. The rationale for this approach is to have a tighter control of the fiscal costs of the scheme. In addition to this, in many cases the allocation of resources is done following a competitive process where resources are allocated according to the merit of the project, until the overall budget for the program is achieved. The trade-off is that many of the administration and compliance costs of the matching grants schemes reappear, sometimes without the benefits of the matching grants system as the decision-making power mainly remains in the firm (if the firm has submitted a project proposal that under the law qualifies as an innovation project, the agency is obliged to issue the tax credit certificate, even when social returns

[16] The fiscal costs of tax credits in developed countries in terms of forgone revenues have systematically increase over the last twenty years with values in the range between 0.06 % of the GDP in the case of the UK up to 0.29 % of the GPD in the case of France (OECD 2010). For a typical developed country that spends about 2 % of the GDP in R&D of which 60 % is done by the business sector, R&D tax incentives represent a significant part of the this effort (OECD 2010).

of the project are low and not very different from the private ones. Merit-based competition and the setting of fiscal quotas can alleviate this problem).

The remaining section of this chapter will focus on the main results emerging from the evaluation of the different programs that support business sector innovation in LAC. However, before this, we will summarize the main issues with regard to the impact evaluation of fiscal incentives for innovation.

5 Empirical Results Emerging from Impact Evaluations of Fiscal Incentives in LAC

5.1 Some Methodological Considerations

As it is clear from the above discussion, although innovation policies might be justified because the presence of many different market, coordination and institutional failures; successful implementation makes strong demands on governments' ability to design programs that would rectify the identified failures. In real life, governments face informational constraints that may be as or more severe than those of firms. Firms and innovation projects are highly heterogeneous. This means that a policy that is optimal in the strict sense of achieving Pareto efficiency should vary not only from firm to firm, but also from project to project. This puts administrating agencies under a severe informational stress (Toivanen 2009). In summary, although there might be a strong case of innovation policies, actual implementation could easily lead to the wrong results or in other words public support could lead to crowding out of private funding.

One of the first issues to be defined in an impact evaluation is how and when to measure the effects of the program, i.e., the outcomes of interest. In the spirit of the CDM model (Crepon et al. 1998), a distinction can be made between innovation input indicators and economic performance indicators. Innovation input indicators are the indicators more directly affected by the intervention. For instance, for a fiscal incentives program, an innovation input indicator is total investment in innovation by the beneficiary. While the relationship between the subsidy and the total investment seems in principle almost tautological, our previous discussion clearly highlight that this is not necessarily true (see, e.g., David et al. 2000). In other words, in the extent that innovation policies are able of changing the firm's marginal cost of capital and to the extent that investment decisions react to this change in the cost of capital we might be able of identifying the extent to which innovation policies generate *input additionality*.

However, just assessing whether innovation efforts increase as a consequence of a subsidy is not enough for policy evaluation purposes. The whole portfolio of innovation projects held by the firm is normally affected. As a result of this, projects with different productivity might be executed, while others might be postponed. So, assessing the outputs of innovation investments is also important (*output additionality*).

Innovation outputs are variables where the concrete realization of innovation activities is observed and their impacts on economic performance materialize. So, in particular in the case of business innovation programs, important output variables to measure *output additionality* are, for example, productivity growth, employment, wages, and exports to just cite a few.

We close this section with a short consideration to the issue of when impacts should be measured. Normally, input additionality is measured in the short term, which is while the innovation project is being implemented. However, in the case of output additionality, a "time to build" period is necessary as to find impacts. More generally, the impact of different programs may display very different patterns over time. An intervention may generate a one-shot increase in the outcome and may have strong impacts that fade out progressively with time; the impact of a program may only appear after a certain period or may even generate an initial drop in the outcome that is later overshot by increases in subsequent years. As a result, a proper consideration of the timing of the effects is crucial in an impact evaluation setting, and failures to account for these issues may lead to misleading conclusions and policy recommendations. A clear distinction should be made between short-run and long-run effects to properly evaluate the costs and benefits of a public program.

Even after carefully considering and selecting the relevant outcomes and indicators, evaluating the impacts of public programs is not a trivial task, especially when the interpretation of the relationship between program participation and the outcomes of interest is to be causal. In impact evaluation, the main definition of causality is based on the concept of *counterfactuals*. For instance, suppose a firm receives a subsidy for innovation investment, and suppose we observe the value of a given outcome of interest for that firm. Then, the public subsidy is said to have a causal effect if the outcome of the firm in the absence of subsidy, but *holding everything else equal*, would have been different. In other words, the program or "treatment" has a causal effect if the observed outcome when the firm receives a subsidy is different from the *counterfactual outcome*, i.e., the outcome that would have been observed if the firm did not receive the subsidy. While this definition of causality is relatively simple and intuitive, it introduces a serious problem from an empirical point of view, because the counterfactual outcome, by definition, is never observed. In other words, if a firm receives a subsidy, it is impossible to know with certainty how this firm would have done it without it. This problem can be approached by setting a control group of firms that did not receive support from the program (and from any other program) selected in a way as to minimize all the observable differences among both groups.

Each one of the evaluations that we review in this chapter is based on a unique dataset where both primary sources of information on beneficiaries are linked to secondary sources of information such as innovation and industrial surveys. This procedure allowed to exactly identifying the specific firms that participated in each evaluated program. In addition, in all the cases, the control group was constructed using a sample of firms that did not receive any other comparable treatment in order to maximize the accuracy of the impact estimation. Moreover, all the evaluations tried to identify comparable treated and non-treated firms in order to minimize the

effect of potential "selection biases" on the evaluation results. A control group was identified using a number of different methods: propensity score matching procedures, difference-in-differences estimation, fixed effect panel data estimation, and instrumental variables methods.[17] All the evaluations are done at the beneficiary level rather than at the project level.

5.2 A Meta-analysis of Evaluation Results

We first summarize the results on input additionality by looking at the impacts of the different programs on firm's innovation investment and we try inferring the extent to which there might be crowding-in or out effects on private investment. We also provide some information on the impact evaluation methodology actually being used. After this, we focus our attention on the impact on output additionality and in particular the extent to which over a longer time period any impact on productivity can be observed. As a caveat, it is important to say that the heterogeneity of available information and data sources did not allow the studies reviewed here to adopt identical estimation techniques for all impact evaluations. As a consequence, results are sometimes not fully comparable across the different cases.

5.3 Input Additionality

Similarly to other regions, the evaluation of input additionality has been the preferred approach for impact evaluation in LAC. Table 1 summarizes the results of 13 impact evaluations done so far in the region. In seven of the studies (summarized in the top half of the table), the main impact indicator variable is the absolute value of firm's innovation or R&D investment (in log). In five of these cases, the main dependent variable is private R&D or innovation investment; in other words, the impact indicator is investment net of the subsidy, while in the two remaining cases the studies looked at total investment in innovation or R&D.[18] The bottom half of the table, on the other hand, summarizes six studies where the main indicator of interest is innovation intensity, that is innovation or R&D expenditures as a fraction of sales or total investment. In two of these cases, the results refer to innovation intensity efforts net of subsidy. In the remaining ones, the results look at the impacts in total innovation efforts.

[17] For more details, see Hall and Maffioli (2008) and Crespi et al. (2011).

[18] In these two cases, the crowding-in/out analysis is less precise. In this case, some assumptions need to be done with regard to the potential way on how the subsidy might it have been disbursed for a representative plant and also with regard to the project duration. In these cases, the assumed project duration relates to the one specified in the grant contract. This approach will surely underestimate the actual length of the typical innovation project.

Table 1 Input additionality—testing for crowing-in/crowding-out effects

Country	Evaluation period	Program name	Intervention	Beneficiaries	Indicator	Impact	Crowding in/out	Method
Argentina (1)	1994–2001	FONTAR-TMP1	Subsidized loan	Firms	ln (Total R&D)	0.15**	In	FE-IV
Argentina (2)	1998–2006	FONTAR-ANR	Matching grants	Firms	ln (Private InnovExp)	0.18*	In	FE-CS
Panama (3)	2000–2003	FOMOTEC	Matching grants	Firms	ln (Total R&D)	0.15**	No evidence	FE-CS
Uruguay (4)	2000–2006	PDT-I	Matching grants	Firms	ln (Private InnovExp)	0.84**	In	FE-CS
Mexico (5)	2004–2007	EFIDT	R&D tax credit	Firms	ln (Private R&D)	0.25**	In	FE
Colombia (6)	2000–2002	Tax Incentives	R&D tax credit	Firms	ln (Private R&D)	0.06**	In	SM
Argentina (7)	1995–2001	FONTAR CFF	R&D tax credit	Firms	ln (Private R&D)	0.13***	In	FE
Argentina (8)	2001–2004	FONTAR-ANR	Matching grants	Firms	(Total R&D intensity) %	0.18**	No evidence	DID-PSM
Brazil (9)	1996–2003	ADTN	Subsidized loan	Firms	(Private R&D intensity) %	0.66**	In	PSM
Brazil (10)	1999–2003	FNDCT	Matching grants	Firms and UNIV	(Private R&D intensity) %	1.63**	In	PSM
Chile (11)	1998–2002	FONTEC	Matching grants	Firms	(Total R&D intensity) %	0.74*	Partial out	DID-PSM
Panama (12)	2006–2008	SENACYT	Matching grants	Firms	(Total R&D intensity) %	0.13**	In	PSM
Colombia (13)	2002–2003	COFINANCIACION	Matching grants	Firms and UNIV	(Total R&D intensity) %	1.20*	In	PSM

Source fixed-effects, instrumental variable (*FE-IV*), fixed-effects and common support (*FE-CS*), fixed effect (*FE*), structural modelling (*SM*), difference in difference–propensity score matching (*DID-PSM*), propensity score matching (PSM). (1) Chudnovsky et al. (2006), (2) Lopez et al. (2010), (3) Maffioli et al. (2011), (4) Lopez and Rossi (2010), (5) Calderón (2010), (6) Mercer-Blackman (2009), (7) Binelli and Maffioli (2006), (8) Chudnovsky et al. (2006), (9) De Negri et al. (2006a), (10) De Negri et al. (2006b), (11) Benavente et al. (2008), (12) Crespi et al. (2011), and (13) Crespi et al (2011). In the case of the evaluation of SENACYT-Panama, total R&D intensity is computed as R&D as a fraction of total innovation sales. *** 1 % significance level, ** 5 % significance level, and * 10 % significance level

Several clear results emerge from Table 1. In first place, the evidence across the different studies is that fiscal incentives clearly stimulate innovation or R&D investments in the LAC region. In all the cases, and regardless the main indicator variable, it was obtained a positive and significant average treatment effect on the treated. In other words, firms that received some sort of fiscal support did increase their innovation investments. Based on the arguments made earlier, this implies that the programs in general are well focalized in the extent that they seem to be targeting firms with either serious appropriability or financial constraints problems or both. So whenever these constraints are relaxed, firms react favorably increasing their investment in innovation. Furthermore, there are seven evaluations where the main impact indicator is the private investment in innovation or R&D, and the results for this variable are also positive and significant, suggesting that companies that receive fiscal support also react increasing their own investment in innovation. As it was mentioned above, this result might be the consequence of the operation of many different transmission mechanisms. In first place, fiscal support might be targeting riskier projects, and so this might induce private finance for follow-up less risky investments. On the other hand, public support might be targeting infrastructure projects, so reducing the subsequent capital costs of any subsequent project. Finally, the fiscal incentive might have a signaling effect on the quality of the project and the research team, so allowing the firm to leverage additional resources from the financial markets. Moreover, qualitative interviews that were part of the evaluation of the Chilean FONTEC, suggest that this signaling effect was indeed important (see Benavente et al. 2007).

With regard to the differences between instruments, it is also observed that the only three cases where there was no evidence of crowding-in (in two cases, there was no evidence on crowding-in nor out, while in just one remaining case there was some weak evidence of partial crowding-out) correspond to variations of the matching grant scheme. Indeed, it seems that subsidized loans or tax credit schemes are clearly more able of generating multiplier effects on private investments. So, there is some evidence that in the extent that matching grants programs provide financing a zero costs this might reduce the potential multiplier effect of the fiscal scheme. However, an important qualification is needed in this case. There are two cases where the matching grant designs have had the highest positive impact on investment—even in comparison with the other instruments—and also the largest multiplier effect with regard to leveraging private investment in innovation. These are the cases of the Brazil's FNDCT and Colombia's Cofinanciacion programs where the main characteristic is that in both cases the scheme provides conditional funding for firm–university collaboration. So, it seems that matching grants programs are particularly well suited to also encourage the building of linkages among the different actors of the innovation system. This particular feature of these two programs could have contributed to the addressing of both financial and technical constraints (lack of human resources, lack of own specialized research infrastructure, and lack of technical knowledge, among others). The relaxation of these other technical constraints might have led to a multiplier effect in private funding.

One important limitation in particular during the earlier evaluations was that sample size did not allow for assessing the extent to which impacts were heterogeneous according to different sub-groups of firms. However, in the case of the Argentina's FONTAR-ANR program, the sample size was large enough has to assess whether there was impact heterogeneity according to firm's experience with managing innovation projects. The evaluators found that although the program does not provide evidence of a multiplier effect at the aggregate level, the data indicate that new innovators have seen a substantial increase in their private investment in R&D. On the other hand, the effect of the matching grants is smaller in the case of more experienced innovators, for which some evidence of displacement of resources was found. In other words, although very limited, the evidence seems to point out toward a favorable impact of matching grants on firms with limited experience on the formulation and execution of innovation projects (Chudnovsky et al. 2006).

Finally, the different evaluations do not find any systematic differential impacts between the other two instruments: tax credits and subsidized loans. In both cases, there are crowding-in multiplier effects and the total the impacts on the firms' total innovation investments are rather similar. As it is possible to infer from Table 1, the majority of the studies make use of propensity score-based techniques in order to find similar treatment–control pairs and select a common support for the impact evaluations. This allows assessing which the main determinants that affect the probability of being selected into any of these programs are. Across many of the studies, it seems that firms with higher levels of human capital or some previous experience in managing R&D and innovation programs are more likely to be selected. In some extent, this is expected, given that in all the cases agencies' technical evaluators highly weighted these two indicators at the moment of scoring each proposal. The problem of an excellence-based selection system is that it is highly meritocratic and what it might be seen as a good result in the short run, it could trigger unexpected dynamic effects in the longer term. Indeed, a heavily meritocratic evaluation system might lead to the selection of only very good candidates, candidates that might be selected again in future competitions. This might trigger a sort of "Matthew Effect" dynamics that might end up affecting competition and inequality through the formation of powerful elites. More research is needed in order to assess whether these endogamy effects are present or not, but this is an issue that requires some follow-up in the near future. In other words, it is important to keep clear exit strategies in the different schemes and to make it transparent to the firms that support has a ceiling. This ceiling should be located just at the right level as to foster excellence but at the same time without compromising variety. The matching grant instrument seems to be particularly well suited to keep the right balance between excellence and diversity.

Are the LAC results very different from the international evidence? Several reviews done on the impacts of fiscal incentives on business innovation investments tend to also reject the full crowding-out hypothesis. David et al. (2000) and Klette et al. (1999) provide a comprehensive review of the main empirical studies measuring the impact of public funding on firms' investment in innovation

during the 1990s in developed countries. According to David et al., two-thirds of the studies report that public R&D funding did not substitute private R&D investments. In the last decade, this kind of analysis has proliferated, thanks to the increasing availability of data, providing some additional insights into the effectiveness of public support of private innovation. Aschoff (2009) provides an updated review of the most significant results. Most of them confirm the absence of full crowding-out effects, and some also show evidence of multiplier effects on private investments. In summary, the LAC region compare quite well with regard to the international evidence on the effectiveness of fiscal incentives on input additionality.

5.4 Output Additionality

At the international level, fewer studies analyze the effect of public support on innovative output (patents, numbers of new products, and sales of new products) and firm performance. Although some positive effects are detected, the results are less conclusive. The main difficulty in this case is that a longer time horizon is required to detect these effects. In fact, while crowding-out or multiplier effects can be detected almost in conjunction with the receipt of public financing, other effects are detectable only after the innovation, learning process and the intra-firm diffusion of the technology have come to an end. This implies that rigorous impact evaluations of these effects may require panel data for a minimum period of at least five years after the receipt of public financing. LAC evaluations do not escape to this problem either. In many of the evaluations carried out by the IDB between 2005 and 2007 (IDB 2007) and summarized by Hall and Maffioli (2008), the studies do not find consistent effects on patents or new product sales and the evidence on firm performance is also mixed with positive results in terms of growth but little corresponding impact on measures of productivity. As it was mentioned before this could be due to the fact that in many if these evaluations output additionality is asked with reference to the same time period during which the innovation project is taking place. So, the time span for evaluating output additionality might have been too short.

In order to fill this knowledge gap, the IDB is currently re-assessing many of the programs mentioned in Table 1 over a longer period and looking at what sorts of impacts these interventions have had in labor productivity growth. The following programs have already been re-assessed: COFINANCIACION (Crespi et al. 2010), FOMOTEC (Maffioli et al. 2011), and two for Chile FONTEC and FONDEF (Alvarez et al. 2011). The implementation of these longer-term evaluations required a close articulation with National Offices of Statistics. Indeed, one of the drawbacks of the previous evaluations was that the same were based on linking beneficiary data with innovation surveys. However, even though innovation surveys are important tools to gather information on innovation investments (and so to assess input additionality), sampling is normally based on repeated cross sections of randomly selected firms. This makes the following of firms over longer time periods almost impossible.

In order to lift these data constraint problem, the evaluators have been working with national statistics offices and linking beneficiary data with business registers data, a process that allows following firms for a very long time period. One limitation of this approach is that data linking can only be done on already existing data registers. So, in this case, the results are somehow restricted to the analysis of manufacturing firms and firms with more than 10 employees.

The results for the four evaluated programs are summarized in Table 2. In this case, all the programs were evaluated using the same methodological approach with the main output indicators being labor productivity. In all the cases, the main dependent variable is in log. The results suggest an important impact of the fiscal incentives on firm performance with increases in labor productivity between 13 % in the case of Panama (which corresponds to the shortest time period) and 15 % in the case of the Colombian program. The results are significant to the standard levels. The two Chilean programs are in between with productivity increases between 9 % in the case of FONTEC and 12 % in the case of FONDEF. Having two programs in the same country is also interesting because it allows for making a closer comparison among them. In particular, we could explore whether there are important synergies among the two programs. In order to explore this, in the sample there is a small but still important group of beneficiaries that make use of both programs. So, we re-explored the analysis for Chile, taking into consideration the existence of three treatments or interventions: (1) firms that applied only for FONTEC, (2) firms that applied only for FONDEF, and (3) firms that made simultaneous use of both programs (FONTEC + FONDEF). We found strong evidence as two suggests there are important synergies among the two programs. Indeed, companies that received the FONTEC only treatment showed productivity increases of 6 % (and not significant), while firms that made use of the FONDEF only approach showed productivity increased of 10 % (and significant). On the other hand, firms that used both programs had a productivity growth of 24 % and significant.

In order to explain the differences between FONTEC and FONDEF, we need to consider the main characteristics of both programs. In the case of FONTEC is the typical matching grant scheme for business innovation projects and where projects are selected based on an open window system. In the case of FONDEF, we are facing a program that gives grants to support university–firm collaboration and where the selection is based on competition.

We systematically found that FONDEF firms have had a higher impact on productivity than FONDEF firms, this could be due to either the incentives for collaboration (that reduces other market failures in addition to lack of finance), or the nature of the competitive process used for the allocation of the resources. We also found evidence that there are important complementary effects among both programs and that FONTEC produces its higher return when it is implemented together with FONDEF. In other words, we found that a combination between an incentive for U-I collaboration (that might be targeting a coordination failure) with an incentive to the firm (that could be targeting an appropriability or financial constrain problem) seem to be the best combination.

Table 2 Output additionality—testing for productivity impacts

Country	Evaluation Period	Program name	Intervention	Beneficiaries	Indicator	Impact	Method
Colombia (1)	1995–2007	COFINANCIACION	Matching grants	Firms and UNIV	Labor Productivity	0.15***	FE-CS
Chile (2)	1998–2006	FONTEC	Matching grants	Firms	Labor Productivity	0.09***	FE
Chile (2)	1998–2006	FONDEF	Matching grants	Firms and UNIV	Labor Productivity	0.12***	FE
Chile (2)	1998–2006	FONTEC only	Matching grants	Firms	Labor Productivity	0.06	FE-CS
Chile (2)	1998–2006	FONDEF only	Matching grants	Firms and UNIV	Labor Productivity	0.10***	FE-CS
Chile (2)	1998–2006	FONDEF + FONTEC	Matching grants	Firms and UNIV	Labor Productivity	0.24***	FE-CS
Panama (3)	2000–2003	FOMOTEC	Matching grants	Firms	Labor Productivity	0.13*	FE-CS

Source fixed-effects and common support (*FE-CS*) and fixed-effects (*FE*). (1) Crespi et al. (2011), (2) Alvarez et al. (2011), and (3) Maffioli. *** 1 % significance level, ** 5 % significance level, and * 10 % significance level

In the cases of COFINANCIACION and FOMOTEC, it was also possible to track the impacts along time by looking at the time since exposure to the treatment. The results provide evidence that these effects remain and, in some cases, increase over time, with these effects becoming more significant between three and five years after the firms started being treated. These findings suggest that longer-term impact evaluations enable the detection of impacts on some of the most relevant variables of interest. This does not necessarily mean that final impact evaluations should be carried out five years after the project's execution. Evaluations could focus instead on the first cohorts of treated firms, so that by the end of a program, some results on performance could also be assessed. This is precisely the approach taken by the US Congress for the evaluation of the Small Business Innovation Research (SBIR) program. The moment the program was approved in the early 1980s, Congress asked the Small Business Administration (SBA) to ensure that beneficiaries of the first three cohorts be followed up over the next decade (Lerner 1999).

6 Conclusions and Emerging Issues

This chapter presents the most important recent trends with regard to the design and evaluation of public policies for the support of business innovation in LAC. Several countries in the region have been experimenting with these policies since early 1990s. In contrast with the OECD countries, the LAC's innovation support framework is clearly biased toward direct transfers to the private sector. Just a few countries have more recently started to experiment with tax incentives. And even in the case of the most important direct support instrument such as the matching grants, the fiscal budgets allocated to these programs are rather meager. In some extent, business innovation policy in the region is still in its infancy.

Many of these pilot programs have already been assessed, and this chapter takes advantage of the existent wealth of studies in order to provide a qualitative meta-analysis of the most pioneer programs in operations since early 1990s. The main conclusions are rather straightforward: *there is a clear evidence of a positive impact on input additionality*. In other words, fiscal incentives have been effective at the moment of increasing firms' investment in innovative projects, and they have been also effective in leveraging private resources for this investment. The studies also found that different financing mechanisms have varying impacts on different group of beneficiaries. Although it seems that the risks of crowding-out private investments are lower in the case of programs based on subsidized loans or tax incentives, matching grants seems to be more effective in the case of new innovators or at the moment of fostering linkages between firms and universities, which suggests the need for focusing these programs on these two issues. With regard to output additionality and productivity, impacts also seem to be positive whenever enough time has elapsed since the grant was approved. Indeed, the different studies that looked at output additionality suggests that positive impacts in labor productivity start to show up only after three to five years since the start of an innovation project.

The previous review also raised several questions with regard to the actual design and implementation of business innovation programs. We close this chapter with a short reference to these emerging issues.

1. The multilevel governance of business innovation policies.

Several LAC countries—in particular the largest ones—are taking important steps toward the decentralization of policy decision making toward provincial and local governments. Indeed, these are the cases of countries such as Argentina, Brazil, Chile, Colombia, and Mexico. In these countries, fiscal incentive programs that operate at the local level are starting to coexist with national or federal level programs. This coexistence of multilevel innovation interventions is also characteristic of some territorially big developed countries such as Canada and the USA. Based on the OECD experience, although in principle sub-national innovation fiscal incentives increases the overall generosity of the support provided to the firm and so they seek to increase the innovation investment performed by local firms, the overall effect is not clear, in particular whether the net effect would still be positive after taking into consideration the decreasing innovation performance in neighboring regions (OECD 2010). In other words, the overall result might not be the expected one. For example, there has been a proliferation of R&D tax incentives among the US states during the last 20 years. Wilson (2009) analyzes the impacts of these state-level schemes and finds that although these incentives are effective in increasing in-state R&D, almost all of such increase is due to R&D being drawn away from other states suggesting a zero-sum game in the aggregate (a gain in one state would be off-set in another state). The risks of ending up in a similar situation in LAC countries should not be ignored. So, more research needs to be done and better data collection needs to be put in place in the region in order to tackle this multilevel governance issue.

2. Can the current set of innovation policy instruments foster entrepreneurship?

There are number of obstacles that might hinder the use of innovation policy instruments in the promotion of entrepreneurship. One is that subsidies are normally paid ex-post against receipts. If it is the case that entrepreneurs are credit constrained, this type of funding may be of little help for them. Second, the speed at which decision making is normally done within the region's innovation agencies may be too slow for a start-up (Toivonen 2009). Previous evidence from developed countries finds that subsidy application costs decline with the size of the firm. And in the case of tax credits even when the application costs are lower, the fact that many start-up firms do not have taxable income yet might also reduce the effectiveness of a tax-based incentive for these types of firms. Despite these limitations, there are two potential advantages of direct subsidies for the support of entrepreneurship. On the one hand, in the extent that direct subsidies are assessed on project basis this could trigger a signaling effect on the quality of the innovative idea for the financial sector, relaxing the severity of the financial constraints (Lerner 1999). On top of this, the implementing agencies might design the matching grants targeting collaboration between large firms and universities with new technology-based firms, linkages

that could also help reducing the development constraints faced by start-up firms. On the balance, it is an empirical matter the extent to which direct subsidies might stimulate entrepreneurship as well; however, the very limited evidence on this emerging from the FONTAR-ANR program reviewed above suggests that matching grants might have some potential for new innovators.

Finally, even when they could have some effectiveness, it could be that matching grants might not be the first best intervention to foster entrepreneurship in the extent that, perhaps the main constraints are the lack of an entrepreneurial culture (and related human capital) at it seems it is the case in many developing countries or the lack of sufficient financial instruments (such as guarantee funds or venture capital funds). In some extent, the effectiveness of the matching grant instrument to foster entrepreneurship will depend on the complementarities among them and all the other set of financial and human capital instruments.

3. The consideration of special characteristics of the service sector.

Although services dominate economic activity, they have long remained under-researched by analysts of innovation policies. During the last ten years in developed countries, however, there has been an increasing interest in understanding innovation in services. Results emerging from this research suggest that services innovate differently than in manufacturing (e.g., less based on R&D and more based on informal arrangements, the adoption of ICTs and user–producer interactions) and that "one fits all" theories on innovation in services might be misleading in the extent that they are a diverse group of sectors both with regard to production and innovation (Tether 2003). In contrast with this evolving body of knowledge, there are no systemic studies of innovation in services in LAC yet. The imperative for understanding the determinants of innovation in services and assessing those market failures that might hinder innovation in these sectors is clear as the service sector employs a significant proportion of the workforce, but its under-performance has been identified as pulling down aggregate productivity levels (IDB 2010a, b). The innovation policy dilemma is clear, if services innovate differently from manufacturing, proper support, and encouragement for innovation in this sector may necessitate new policy designs and programs. Filling the knowledge gap on the determinants of innovation and productivity in services requires improving in data collection efforts. Although some countries in the LAC region have just started collecting data on innovation in services, this emerging evidence has not been yet properly assessed.

References

Aghion P et al (2009) Science, Technology and Innovation for Economic Growth: Linking Policy Research and Practice in STIG Systems. Res Policy 38:681–693

Alvarez R et al (2011) Employment, firm size and innovation in Chile: The Microeconometric Evidence. IDB

Arrow KJ (1962) The Economic Implications of Learning by Doing. Rev Econ Stud 29(3):155–173

Aschoff B (2009) The effect of subsidies on R&D investment and success: do subsidy history and size matter? ZEW Discussion Papers 09-032. Zentrum für Europäische Wirtschaftsforschung
Benavente JM et al (2007) Public Support to Firm Innovation: The Chilean FONTEC Experience. OVE Working Papers 0407. IDB
Bresnahan T, Tratjenber M (1995) General Purpose Technologies: Engines of Growth? J Econometrics 65
Binelli C, Maffioli A (2006) A Micro-econometric Analysis of Public Support to Private R&D in Argentina. Int Rev Appl Econ 21(3):339–359
Calderón-Madrid A (2010) A Microeconometric analysis of the Impact of Mexico's R&D Tax Credit Program on Private R&D Expenditure. Manuscript. Colegio de México, Mexico
Chudnovsky D et al (2006) Evaluating a program of public funding of private innovation activities. An Econometric Study of FONTAR in Argentina. OVE Working Papers 1606. IDB
Cohen W, Levinthal DA (1989) Innovation and Learning: The two faces of R&D—Implications for the Analysis of R&D Investment. Econ J 99:569–596
Crepon B et al (1998) Research, Innovation, and Productivity: An Econometric Analysis at the Firm Level. Economics of Innovation and New Technology 7(3):115–156
Crespi G, Zuniga P (2011) Innovation and Productivity—Evidence from Six Latin American Countries
Crespi G et al (2010) Business Support to Innovation. The Colombian COLCIENCIAS' Experience. IDB TN 264. IDB
Crespi G et al (2011) Evaluación del Impacto de Corto Plazo en la Innovación de las Empresas Panameñas. IDB TN 264. IDB
Crespi G et al (2011) Evaluating the Impact of Science and Technology Projects: a Methodological Toolkit
Criscuolo C (2009) Direct and Indirect Effects of Innovation Policy
David P et al (2000) Is Public R&D a Complement or Substitute for Private R&D? A Review of the Econometric Evidence. Res Policy 29:497–529
De Luis MJ (2010) Methodology for Measuring the Fiscal Effect of Regional Tax Expenditures in Colombia. Discussion Paper IDB DP 139. IDB
Disney R et al (2003) Restructuring and Productivity Growth in UK Manufacturing. Econ J 113:666–694
De Negri JA et al (2006a) Impact of R&D Incentive Program on the Performance and Technological Efforts of Brazilian Industrial Firms. OVE Working Papers 1406. IDB
De Negri JA et al (2006b) The Impact of University Enterprise Incentive Program on the Performance and Technological Efforts of Brazilian Industrial Firms. OVE Working Papers 1306. IDB
Fabegerber J, Verspagen B (2002) Technology gaps, innovation diffusion and transformation: an evolutionary approach. Res Policy 31:1291–1304
Griffith R et al (2001) Measuring the Cost-Effectiveness of an R&D Tax Credit for the UK. Fisc Stud 22(3):374–399
Hall B, Lerner J (2010) The Financing of R&D and Innovation. In: Hall BH, Rosenberg N (eds) The Economics of Innovation. North Holland, Amsterdam
Hall B, Maffioli A (2008) Evaluating the Impact of Technology Development Funds in Emerging Economies: Evidence from Latin America. NBER Working Paper Series 13835
Hall B, Van Reenen J (2001) How effective are fiscal incentives for R&D? A review of the evidence. Res Policy 29:449–469
Harris R et al (2009) Is a higher rate of R&D tax credit a panacea for low levels of R&D in disadvantaged regions? Res Policy 38:192–205
Inter-American Development Bank (2007) IDB's Science and Technology Programs: An Evaluation of the Technology Development Funds and Competitive Research Grants. OVE Evaluation Report. IDB
Inter-American Development Bank (2010a) The Age of Productivity. Transforming Economies from the Bottom Up. IDB, Washington DC

Inter-American Development Bank (2010b) Science, Technology and Innovation in Latin America and the Caribbean: A Statistical Compendium of Indicators. IDB, Washington DC
Inter-American Development Bank (2011) Sistemas regionales de innovación en América Latina. IDB, Washington DC
Klette TJ et al (1999) Do Subsidies to Commercial R&D Reduce Market Failures?—Microeconomic Evaluation Studies. Harvard Institute of Economic Research Working Papers 1861
Lerner J (1999) The Government as Venture Capitalist: The Long-Run Impact of the SBIR Program. Journal of Business 72(3):285–318
Lopez A, Rossi M (2010) Evaluación de Impacto de un Programa de Financiamiento Público a Actividades de Innovación en Uruguay. Programa de Desarrollo Tecnológico
Lopez A et al (2010) Impact Evaluation of a Program of Public Funding of Private Innovation Activities. An Econometric Study of FONTAR in Argentina. OVE Working Paper 03/10. IDB
Lundvall B-A (1992) National Systems of Innovation: Towards a theory of Innovation and Interactive Learning. Pinter, London
Maffioli A et al (2011) Public Support to Firms' Innovation: The FOMOTEC Experience in Panama. IDB TN. IDB
Martin S, Scott J (2000) The nature of innovation market failure and the design of public support for private innovation. Res Policy 29:437–447
Mercer-Blackman V (2009) The Impact of Research and Development Tax Incentives on Colombia's Manufacturing Sector: What Difference Do They Make? IMF Working Paper WP/08/178. IMF
Metcalfe (1995) Technology Systems and Technology Policy in an evolutionary framework. Camb J Econ 19:25–46
Nelson R (1959) The Simple Economics of Basic Scientific Research. J Pol Econ 67:297
Organization for Economic Co-Operation and Development, Eurostat (2005) Oslo Manual. The Measurement of Scientific and Technological Activities. Guidelines for Collecting and Interpreting Innovation Data. OECD/Eurostat, Paris
Organization for Economic Co-Operation and Development (2010) R&D Tax Incentives: Rationale, Design and Evaluation. OECD/Eurostat, Paris
Roca J (2010) Evaluation of the Effectiveness and Efficiency of Tax Breaks. Institutional Capacity and Finance Sector, Discussion Paper IDB-DP-136. IDB
Soete L et al (2010) Systems of Innovation. In: Hall BH, Rosenberg N (eds) The Economics of Innovation. North Holland, Amsterdam
Steinmuller E (2010) Economics of Technology Policy. In: Hall BH, Rosenberg N (eds) The Economics of Innovation. North Holland, Amsterdam
Stiglitz JE, Weiss A (1981) Credit Rationing in Markets with Imperfect Information. Am Econ Rev 71(3):393–410
Tether B (2003) The Sources and Aims of Innovation in Services: Variety Between and Within Sector. Economics of Innovation and New Technology 12(6):481–505
Toivanen O (2009) Innovation Policy. Entrepreneurship and Development: A Finnish View. UNU-MERIT Working Paper Series 2009-050
Van Pottelsberghe B et al (2009) Evaluation of Current Fiscal Incentives for Business R&D in Belgium. Université Libre de Bruxelles/Solvay Business School/Centre Emile Bernheim, Working Paper WP-CEB-03/011
Wilson D (2009) Beggar Thy Neighbor? The In-State, Out-State and Aggregate Effects of R&D Tax Credits. Rev Econ Stat 91(2):431–436

Science, Technology, and Innovation Policies for Inclusive Development: Shifting Trends in South America

Isabel Bortagaray and Natalia Gras

Abstract This chapter analyzes the linkages between science, technology, and innovation (STI) policies and inclusive development. These connections are first studied from an analytical perspective and then through four current STI programs in the South American context. STI policies are increasingly framed and approached in relation to social inclusion and development. Learning from these experiences is of utmost importance both analytically and policy-wise. This work attempts to contribute to this learning process.

1 Introduction

In what ways could science, technology, and innovation (STI) help to overcome some of the main challenges of South America's development? How could STI policies promote social inclusion in these countries? More specifically, what policies could substantially contribute to expand people's choices, and learning capabilities and opportunities, and their inclusion into STI-based development processes? Furthermore, what role and how could other policies and instruments (social, industrial-productive, agricultural, etc.) contribute to that same goal, but intertwined with STI policy? What analytical frameworks and theoretical underpinnings could reinforce this integrative approach and help to better understand the dynamics between STI and inclusive development?

The chapter explores these triggering questions by analyzing the current national plans on STI and their connection to inclusive development in four South American

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countries. It does so, first, by posing some of the key issues that conform the idea of inclusive development. Secondly, it explores the relationship between STI and development. The third section concentrates on the role of inclusive innovations for inclusive development to then analyze the STI policies for inclusive development. Learning from few ongoing experiences in South America is the main issue of the fifth section, before summarizing some of the main final remarks of the chapter.

2 The Path Toward Inclusive Development

Development strategies and thinking entail a normative matter; they rely on principles and values that rule the established set of choices, priorities, and overall means and goals. Following Sen's work, we conceive development as a process for the expansion of human freedoms and capabilities (Sen 1999). This expansion of freedoms is both the principal mean (instrumental role) and the primary end (constitutive role, as it enriches human life) of development. Instrumental freedoms are vehicles for capabilities and are also interconnected and complementary, and one might reinforce others. Examples of instrumental freedoms are political freedom (including civil rights), economic facilities (opportunities to utilize economic resources for consumption, production, or exchange), and social opportunities (arrangements for education, healthcare, etc. that influence substantive freedoms to live better), transparency guarantees (need for openness, freedom to deal with one another), and protective security (a safety net of social protection) (Sen 1999).

Furthermore, development should be assessed based not only on achievements but also on the ability to achieve. It is not only about achievements but also about freedom to achieve, or *realized* functions (actual ability to perform) and the *capability* set of alternatives (real opportunities) (Sen 1999). Capabilities and functions are intrinsically and mutually related. While for Sen the latter refer to living conditions, capabilities are notions of freedom, that is "…what real opportunities you have regarding the life you may lead" (Sen 1987).

This conceptualization of development has been quite influential in the way development is analyzed and assessed. The UNDP human development approach draws on Sen's approach. The first UNDP report (1990) (UNDP 1990) acknowledged that opportunities are not a constrained set of alternatives; they depend on the historical and social context and do vary over time. Participation and the sustained character of development also appear as key dimensions (UNDP 1992, 1993). Development processes are inclusive when "all groups of people contribute to creating opportunities, share the benefits of development, and participate in decision-making."[1] The International Development Research Center program on Innovation for Inclusive Development conceived inclusive development in very much the same way than UNDP. However, it

[1] UNDP inclusive development: http://www.undp.org/content/undp/en/home/ourwork/povertyreduction/focus_areas/focus_inclusive_development/, last accessed April 1, 2013.

recognized the fundamental need to be more focused and better understand innovation processes in informal settings (IDRC 2011). For Cozzens and Sutz (2012), the concept of inclusive development relates to the inclusion of marginalized groups, their role as "agents and not as patients." The agency is the fundamental feature that qualifies the development process into an inclusive one (Cozzens and Sutz 2012, p. 2).

The linkages between equality, capabilities development, and learning processes are central to understand the concept of development and the role that innovation should play in Sen's approach (Sen 1999). The quest is for policies that connect STI with inclusive development. It is not about any type or modality of development, but one that is rooted on learning processes that lead to the expansions of choices, capabilities, and freedoms, in an inclusive manner. Following Sen (1999), inclusion is both instrumental and constitutive to development. As Cozzens and Sutz (2012) put it, based on Sen, inclusiveness shall be "the main goal of development oriented innovations and the only way such innovations can be achieved" (Cozzens and Sutz 2012, p. 12).

The concept of inclusion is a relational concept, it necessarily relates to the exclusion one. Jiang (2011) defines social inclusion as the reduction in exclusion, which in turn refers to the prevention of participating in the economic production, social relationships, and political activities. In (dynamic) inclusive development processes, individuals have access/can participate in the opportunities and social, political, and economic activities, and share the product in an efficient and equalitarian manner (Ali and Hyun 2007; Ali and Zhuang 2007; Klasen 2010). An empirical study on systems of innovation for inclusive development in China and India has led to the analysis of different forms of exclusion, which get reproduced through structures and policies: spatial exclusion, organizational exclusion, and institutional exclusion (Raina 2011) and for a political articulation around the goals and role of science in society.

3 The Relationship Between STI and Development

STI have been linked to economic growth (Schumpeter 1934; Abramovitz 1956, 1986; Solow 1956; Lundvall 1996), which does not necessarily imply economic development (Sen 1983; Emmerij 1997). Part of the thinking has been that the benefits from STI investments would be efficiently redistributed through the market, leading to more well-being and, therefore, more development. However, the expected process of trickle down from investments on STI does not hold, as it is not even across the population[2] (Arocena and Sutz 2009; Infante and Sunkel 2009;

[2] Hirschman (1986) noted that development does not depend so much on finding the optimal combinations of assets, but it is about resources and capabilities. During the 1970s, the gap between developed and developing countries increased, and promises about its benefits did not take place. On the opposite, poverty and inequality augmented. In Latin America, it has been difficult to conciliate growth with equity, that convergence has been missing, the "empty box" of Latin America's development Fajnzylber (1989). "Industrialización en América Latina: de la 'caja negra' al 'casillero vacío': comparación de patrones contemporáneos de industrialización." Cuadernos de la CEPAL 60.

Cozzens and Sutz 2012; Gras 2012). Development goes beyond catching-up (Cozzens and Sutz 2012), and it could lead toward increasing inequality (Chataway and Smith 2006; Cozzens et al. 2006; Arocena and Sutz 2009). Hence, the question of what types of innovations could lead to inclusive development processes is pertinent and necessary for development strategies. The relationship between innovation and inequality is far from straightforward. This relationship is multidimensional and dynamic. Oftentimes, innovation increases inequality, while at times, the output is the opposite (Cozzens 2006). The analysis of innovation and inequality stands on several dimensions, and the relationship between technologies and employment is one of them. It is not only about the effect of technologies on employment *per se*, but also about the corporate strategies in place, to develop and use the technologies (Lazonick 1998). The main hypothesis of the economic literature on inequality and technology is that there is a skill bias as a result of technological change (Bound and Johnson 1982; Juhn et al. 1991; Card and Dinardo 2002), in which the salaries of the less skilled are negatively affected. Moreover, changes in the structure of demand could harm the poorer (Saint-Paul 2008). Often, the results are mixed: innovations lead to an increase in the equality of opportunities as well as to inequality in income, as employers reward skills and training of the new labor (Galor and Tsiddon 1997).

One of the features of fragmented societies is that a significant share of the population is excluded from the benefits of technological change and innovation, while some, a small portion where income concentration occurs, have living standards comparable to people in industrialized countries (Katz 2006; Arocena and Sutz 2009). In this sense, innovations are to some extent shaped by those in power. Thus, costly innovations that are marketed in unequal contexts tend to benefit small groups, while increasing the socioeconomic gap (IDB 2011).

For a very long time, Latin America's income distribution has been one of the most unequal in the world: during the 1990s and early 2000, inequality remained constant. During 2002 and 2003, there was an inflection point with a decreasing inequality trend in several countries. Still there is a long way to go: the region remains the most unequal in the world (CEPAL 2011). Furthermore, in spite of decreasing poverty and inequality levels, the main causes remain: the increase in salary income and the increase in the public transfer to the most vulnerable sectors. However, rigidity in the productivity gap and the low mobility of the lower productivity sectors remain (CEPAL 2011).

The large heterogeneity of the regional productive structure leads to large disparities between the contribution of each productive sector, both to product and to employment. The close linkage between structural heterogeneity and income inequality prevails as a rigid and sustained pattern. Even if employment in low-productivity sectors has diminished in the last few decades, the distance with regard to employment in the mid- and high-productivity sectors has increased (CEPAL 2011) (Table 1).

Income concentration is a serious concern regarding structural heterogeneity, but not the only one: the "productive divergence" leads to large segmentation of the labor markets, which is reflected in the distinction between high- and low-productivity employment, or between the formal employment (closer to technological frontier, with

Table 1 Structural heterogeneity in Latin America

Level	Size	GDP share (%)	Employment share (%)
High productivity	More than 200 employees	66.9	19.8
Medium productivity	SMEs	22.5	30
Low productivity	Informal sector	10.6	50.2

Source Gras (2012) based on CEPAL data (2011)

higher-level education, better labor conditions, and protection by labor institutions) and the informal (lower income, lower education level, instability, limited social security, and lack of labor contracts) (CEPAL 2011).

In a Latin American context characterized by the absence of active product redistribution policy and transformation of firms' absorptive capacities, a traditional innovation approach could result in the increase in the productivity gap between sectors and thus in the increase in inequality within countries. A reflection on the mechanisms and modalities in which innovation shall contribute to reduce disparities in the access to learning and knowledge benefits becomes imperative, and inclusive innovation, a crucial concept. In the next paragraphs, some of these alternatives are revised.

4 Inclusive Innovations for Inclusive Development

The question of inclusion in relation to innovation and development has had different approaches and emphases. Questions such as whom to include, how to include them, and inclusion to what have had different answers, depending on the approach. Inclusion could result from treating the more disfavored and poorer population as consumers of public policy to satisfy their basic needs, or as consumers of low-cost products provided by large corporations (Prahalad 2005), other firms, or the state (Gupta 2007). Another way of reaching inclusive innovation is through the building of capabilities in the more vulnerable sectors for exploiting their know-how, innovations, and traditional knowledge, or couples that knowledge with the knowledge that is embodied in market products, either directly, or through other firms. Linkages with R&D organizations (commercial or not) also matter for inclusion (Benyacar et al. 2008; Ramani et al. 2010; Iizuka and Sadre Ghazi 2011).

The distinctive character of inclusive innovations is that they are triggered by social demands or needs, and the social objectives are, at least, as important as the economic ones. Thus, the actors involved transcend the firm. The main barrier to implement this type of social or inclusive innovation is the lack of a general framework from which to establish what is the demand or need, how to assess it and satisfy it, how to turn that demand into a source of opportunities for knowledge production. Furthermore, as Fressoli et al. (2011) pose, a comprehensive public policy framework is missing, one that places innovation as an instrument to overcome exclusion problems, and a system of evaluation and monitoring that enables comparison of the effectiveness and efficiency of the different initiatives (Fressoli et al. 2011).

4.1 Research and Policy Approaches

As mentioned earlier, few concepts and policy initiatives related to inclusive innovation have been developed: the *Bottom/Base of Pyramid (BoP)* (Prahalad and Hart 2002; Prahalad 2005), *inclusive business*, *grassroots innovation* (Gupta 2000), *appropriate technology* (Schumacher 1973), *below the radar innovation* (Kaplinsky et al. 2010; Kaplinsky 2011); *pro-poor innovations* (Benyacar et al. 2008; Ramani 2008; Ramani et al. 2010), and *research and innovation oriented to social inclusion IIIS* (Bianco et al. 2010; Alzugaray et al. 2011a, b).

These initiatives have a common understanding that innovation can firmly contribute to social inclusion based on the interaction and coordination of different actors who shall be systemically oriented and engaged in the solution of pressing social problems. However, they differ in their emphases, practices, organization and arrangements, and instruments. They also differ in the normative aspects of inclusion of whom, for what, through what mechanisms. Innovation could lead to inclusive development when it explicitly aims at reducing exclusion. This might happen either when the innovation process is itself inclusive, and/or when the resulting innovation leads toward higher inclusiveness (Departamento Administrativo de Ciencia 2011), though this distinction between process-oriented inclusive innovation and innovations for social inclusion is mainly an analytical resource, while in real life, they overlap and get intertwined.

When inclusion takes place mainly through the innovation process, the goal is the building of capabilities in the more vulnerable sectors of the population, through two main mechanisms: the citizen and community empowerment, or by including these sectors in the productive value chain. The grassroots *innovations* (Gupta 2000), social *technologies* (Dagnino 2010), *technologies for social inclusion* (Fressoli et al. 2011), and research and innovation for social inclusion *(IIIS-CSIC-Udelar) (UNDP* 1992*)* (Bianco et al. 2010) approaches are within the former. The second mechanism is when inclusiveness is more centered on inclusion in the productive value chain. The *inclusive business* and *below the radar* (Kaplinksy et al. 2010; Kaplinsky 2011) streams reflect the latter.

The approach of innovation oriented to social inclusion attempts to improve the access of the more vulnerable population to quality, low-cost goods, which are in turn embedded in local capabilities and needs. The main approaches within this stream are the following: *BoP* (Prahalad and Hart 2002; Prahalad 2005; Hart 2005); *inclusive business*; *below the radar* (Kaplinksy et al. 2010; Kaplinsky 2011); appropriate *technologies* (Schumacher 1973); *pro-poor innovations* (Ramani 2008; Benyacar et al. 2008; Ramani et al. 2010), and research and innovation oriented to social inclusion *(IIIS-CSIC-UdelaR)* (Bianco et al. 2010; Alzugaray et al. 2011a, b).

G*rassroots innovations* entail the building of capabilities in the more vulnerable groups and attempt to increase the citizen's empowerment; it implies a bottom-up approach that places the focus on local knowledge and skills for the development of earlier unavailable solutions, but quality and low-cost ones (BM 2010). On the contrary, the BoP approach (Prahalad 2005) stresses that the large corporations could

maximize their profits by producing goods and services targeted at the bottom of the income pyramid population *(BoP)*. Whereas the former is more bottom-up and considers the poor as potential innovators as the pro-poor innovation approaches does, the BoP, a top-down approach, conceives the poor more as consumers (Iizuka and Sadre Ghazi 2011). The BoP approach places the marginalized population as consumers ("patients") not as agents of change. It is not inclusive in the sense that there is not really a capability building process (Cozzens and Sutz 2012).

The *inclusive business* shares some commonalities with the BoP as they both advocate for business development for benefitting the less-advantaged population. The main contrast is the emphasis on the poor not only as consumers but also as producers, entrepreneurs, and employees, while also calling for the reduction in poverty. It is about seeking solutions to integrate the poorer into the value chain, both on the demand and supply sides. The below the radar innovation approach has some common features with BoP and inclusive *business*. It poses that emerging economies (BRICS) have a relevant role to play on the fostering of innovations oriented to satisfy the demand of lower-income population. It involves rather top-down technology transfer processes (Chataway and Smith 2006). It is for this reason that Cozzens and Sutz (2012) consider that the below the radar approach is not aligned with the inclusive development approaches, as it is more about technology transfer rather than capability building or the building of technological solutions.

The *research and innovation oriented to social inclusion* focuses on the knowledge production across all disciplines, for generating potential solutions to alleviate social inclusion related problems. Universities play a crucial role as knowledge production actors. Furthermore, because this approach stresses the relevance of knowledge across all disciplines, results could contribute not only to generate goods and services but also to the design and implementation of public policies and the identification of necessary interventions to improve the civil empowerment and participation in the community, locality, or specific territory. Depending on the research objectives of the specific project, this approach could be associated to a top-down or bottom-up strategy.

Whereas for the grassroots, *pro-poor*, innovation oriented to social inclusion, and *below the radar innovation* approaches*, the focus is on the interaction of different actors* (NGOs, firms, government, knowledge production organizations, funding agencies, etc.) to reach solutions that improve people's life, the BoP places that role at the large corporation, which orient its strategy to the provision of quality and low-cost goods and services to satisfy BoP demands. Similarly, the *inclusive business* emphasizes the private sector (Iizuka and Sadre Ghazi 2011). Supportive public policies will vary considerable, depending on the approach.

Finally, from the perspective of the diffusion of inclusive innovation, the grassroots approach is based on the demonstration effect that socially oriented organizations could have, and the interaction among sectors. Pro-poor innovations, similarly to BoP, inclusive business, and below the radar innovation, pose diffusion through BoP markets. On the contrary, innovations oriented to social inclusion entail multiple diffusion processes: market, state through public procurement, public policy, and also demonstration effects of best practices in the territory. Table 2 sketches some contrasts between these different approaches.

Table 2 Inclusive innovation: a brief contrast between the different approaches

	BoP	Inclusive business	Grassroots innovations	Appropriate technologies	Below the radar	Social technologies	Pro-poor innovations: example of the eco-toilets	IIIS-CSIC-Udelar
The poor in …	informal economy	Countries with low human development index (HDI)	Rural and semi-urban areas	Third world	India and China	Rural and semi-urban areas of Brazil	India	Uruguay
Type of innovation	Product and business model	Hybrid solutions, organizational innovation	Product adaptation (traditional knowledge)	Low technology and small scale	Disruptive innovation, new markets	Product adaptation (traditional knowledge)	Product adaptation (traditional knowledge)	Product, organizational, institutional
Reference to innovation/ technology	a	a	c	c	c	c	c	c
Main agents	Multinationals and NGOs	SMEs, large corporations, funding agencies, NGOs and local community	Government, NGO and local community	NGOs	Private sector, NGOs, local community	Government, funding agencies, NGO and local community	Government, funding agencies, firms, NGO, and local community	Universities, NGOs, government, firms and local community
Increase in private profits	c	b	a	a	b	a	a	a

(continued)

Table 2 (continued)

	BoP	Inclusive business	Grassroots innovations	Appropriate technologies	Below the radar	Social technologies	Pro-poor innovations: example of the eco-toilets	IIIS-CSIC-Udelar
Poor seen as …	Consumers	Consumers, producers and entrepreneurs	Innovators	Innovation users	Innovators	Innovators	Innovation users	Innovation users
Scale/scope	large	small/medium	Small	Small	Medium/large	small/medium	small/medium	small/medium
Method for poverty alleviation	Provision of goods and services	Involve poor in production activities	Use local innovation to satisfy low needs	Diffuse low-cost local-resource-based technologies to satisfy needs	make innovation accessible and available	Use local innovation to satisfy low needs and develop citizen empowerment	Use local innovation to satisfy low needs	Improve access to innovation and citizen empowerment
Supply-push/demand-pull	*Supply-push*	*Supply-push/Demand-pull*	*Demand-pull*	*Supply-push*	*Demand-pull*	*Demand-pull*	*Supply-push*	*Supply-push/Demand-pull*
Capability building and knowledge production for the poor	Weak	High	Capability building based on traditional knowledge	Weak, empowerment of users	Reduce cognitive barriers	Capability building based on traditional knowledge	Reduce cognitive barriers	Reduce cognitive barriers

Source Gras (2012), based on Iizuka and Sadre Ghazi (2011)
Note the number of asterisks indicates the relevance: [a]*low*, [b]*medium*, [c]*high*

5 STI Policies for Inclusive Development: Choices and Practices

Nowadays, STI policies are widely accepted and framed as drivers of economic growth. The quest for policies that shape the strength and direction of scientific, technological, and innovation capabilities and opportunities is now well established. Across the globe, governments have put in place a set of instruments to nurture their knowledge base and innovativeness, and to expand their ability to absorb new knowledge. The shared realization that STI and economic growth have a strong and positive relationship[3] gets very much blurred when thinking about the relationship between STI and development, which complexity makes it not necessarily a positive relationship. STI could result in widening inequalities, both vertical (income concentration), as well as horizontally (gender, geography, race, etc.) (Cozzens et al. 2006). Inequality problems are mainly social, refer to the unequal distribution of resources in relation to the economic, cultural, and power dimensions and, thus, require social and political solutions in the first place, rather than exclusively technological ones (Sutz 2008).

Furthermore, that strong and shared realization that STI policies are necessary and desirable coexists with other approaches aimed at strengthening the connection between STI and inclusive development. These approaches are now gaining momentum, but there is still need for evidence that shows their ability to make that connection tighter. What STI policies are more conductive to inclusive development is still an open question, and part of experimental processes carried out by few countries. What seems to be clear is that the diversity of contexts and trajectories calls for diverse and plural STI policies, and analytical frameworks. However, the portfolio of instruments and policies aimed at fostering STI has been rather uniform, in spite of large disparities in the trajectories and types of problems faced by developed and developing countries. Whereas the design of a set of policies should respond to the specific nature and type of local problems, needs, demands, and capabilities, the normal practice has been to intervene with rather similar instruments, dismissing their adequacy and responsiveness to local dynamics.

The uniformity in the policy response is not unique to the STI policy arena. As Evans (2004) points out, the theoretical emphasis on institutions as key enablers and drivers of development has been jeopardized by limited institutional strategies that, far from expanding the institutional alternatives, have led to institutional mono-cropping, which "rests on both the general premise that institutional effectiveness does not depend on fit with the local sociocultural environment, and the more specific premise that idealized versions of Anglo-American institutions are

[3] In spite of the theoretical consensus about the positive relationship between innovation and economic growth, empirically there are some differences. While this relationship holds in the context of developed countries, it is not so clear in developing countries where growth historically has been strongly related to the exploitation of natural resources and low-skilled labor, rather than knowledge.

optimal developmental instruments, regardless of level of development or position in the global economy" (Evans 2004, p. 33).

Furthermore, diversity within the STI policy domain must be complemented with the integration and cross-fertilization between policy domains in the attempt to nurture the journey toward inclusive development. If a more inclusive development pathway is at stake, it will necessarily require the articulation and integration of transversal policies with sectorial policies that exceed the STI policy arena: education, economic, environmental, agricultural, industrial, labor, and the social development policy arenas should be part of an integrative and plural approach to STI that lead to inclusive development. The problem to tackle is one of the developments: how to design and implement STI-based "solutions" that lead to development processes which are inherently more inclusive. Any hint to answering this question should start by posing that policy strategies to find development solutions go beyond the strict boundaries of the STI policy domain.

A shift in the conceptualization, approach, and framing of STI inextricably linked to socially inclusive development requires a shift in the policy paradigm (Saint-Paul 2008) and the explicit connection with development strategies (Sagasti 2011). A new agenda for a STI policy explicitly linked to inclusive development is necessary. Policies are about choices: choices of scope, of policy instruments, of distribution, and of restrains and innovation (Heidenheimer et al. 1990). Recent experiences in Latin America indicate a new set of choices, and a reverse trend from that uniform policy response or policy "mono-cropping," to a policy learning by doing and by design, in which few countries are "muddling through" to craft a policy framework and institutional arrangements that connect and foster STI in relation to development.

In the next paragraphs, we analyze the current plans of four countries in South America that have been recently established. In some cases, they have not been fully articulated into detailed instruments, or have they been fully implemented, leaving the policy cycle yet to be completed. These STI-related plans place STI as vehicles for development, and, with more or less intention, are concerned with social inclusion.

In the analysis, we stick to the nominative word of the plans, their intentions, and proposed directions. Plans are declarations of interests, conceptual frameworks that represent visions and missions and set the direction of what to become, ideally. But when put into motion, at the time of design and implementation, the original interests and goals of those plans are somehow changed (lost/gained) in the translation/adaptation process. The translation processes from intentions to practices through instruments, and actual implementation might be quite bumpy, involve deviations and turnarounds. Still, plans are very valuable conceptual pieces when analyzing STI in relation to development, as they speak about how development is conceived at certain point in time, what strategies and choices are made, toward what goals and direction is the development journey set, and how is STI seen in that process, what role is given to STI, and how it is articulated with broader development goals. Thus, the next section introduces the evolution of STI policy context in four countries: Bolivia, Colombia, Ecuador, and Peru, to then concentrate on the analysis of their respective ongoing plans and their connection to social inclusion.

6 Learning from Current Experiences: Evolution of STI Policy in Bolivia, Colombia, Ecuador, and Peru[4]

6.1 Context and Outputs

6.1.1 Ecuador

In Ecuador, the set of activities oriented to STI go back to the 1970s when the Division of Science and Technology, the National System of Science, Technology and Innovation (SNCTI), and the National Council of S&T (CONACYT) were created. By the mid-1990s, CONACYT was suppressed and the National Secretariat of S&T was established as the political entity in charge of the design of STI policies, while the Foundation for S&T became the executive organization.

Only in 1996 did Ecuador set its first STI program, and the planning phase took until 2000. At that time, the STI sector was rather weak, both from the supply and demand perspective as well as in terms of their articulation. The lack of funding resources for STI, and the lack of infrastructure made evident the capacity weaknesses, which were reinforced by a productive structure based on non-knowledge intensive sectors. That first program aimed at strengthening the scientific and technological capabilities by fostering basic and applied research in relation to the priorities of the population to improve their quality of life and to foster innovation and technology transfer that would lead to the country's increase in productivity and competitiveness. The specific objectives were to: (1) contribute to turn STI into a vehicle for overcoming the main problems of Ecuador's society and to rise its quality of life; (2) improve the productive sector's competitiveness; (3) foster the linkages with academia, government, and production; and (4) strengthen the capacity of the National System of Science, Technology and Innovation (SNCTI). However, after the mid-2000, Ecuador still showed severe weakness in its STI capabilities and lack of articulation among the STI-related actors.

Thus, the second plan of STI (2007–2010) was aimed at turning STI as a motor for the productive transformation of Ecuador, and at expanding the production, use, access, and diffusion of knowledge. It is noteworthy that during this time, Ecuador went through a change in the political context. With the advent of Correa as president, the National Development Plan (PND) 2007–2010 was established (also known as the Plan for the Citizenship Revolution), which later would become the National Plan for Good Living 2009–2012 (PNBV). The second STI plan articulated its objectives and programs around a more general vision

[4] This section is based on the STI Plans, more particularly on the background and diagnoses contained in those plans: Bolivia: Programa Plurianual de Ciencia, Tecnología e Innovación: Primera Fase (Santivañez and Fernández 2011); Colombia: Plan Nacional de Desarrollo Científico, Tecnológico y de Innovación (Colciencias 2006); Ecuador: Plan Nacional de Ciencia, Tecnología, Innovación y Saberes para el Buen Vivir (SENESCYT and SENPLADES 2011); Peru: Plan Nacional Estratégico de Ciencia, Tecnología e Innovación para la Competitividad y el Desarrollo Humano.

of development. The PNBV has a holistic and integrative perspective based on the rights approach that goes beyond the more traditional sectoral one. It has a territorial and local development perspective and attempts to articulate local and national objectives. It develops specific policies for the different places depending on the existing capabilities, resources, and local needs, and looking to align local development to national development, and citizen and sectoral participation. Environmental sustainability and gender, intercultural, territorial, and generational equity are crosscutting concerns.

In spite of the upsurge of STI during the period 2007–2010, as a result of the new political context in which STI was framed, and a set of targeted actions to increase the spending on research activities, the training of human resources, and the strengthening of research institutes, the systemic and structural problems of the country remained as a barrier and bottleneck for turning STI into a motor of Ecuador's development.

By 2009 with the reform of the second STI plan, the STI and Knowledge for Good Living Plan 2009–2015 emerged, which is analyzed in the next section.

6.1.2 Bolivia

The processes undergone in the context of the Plurinational State of Bolivia have contributed to place S&T as a national interest, with an emphasis on the collective appropriation of knowledge. In spite of the different strategies developed during the last four decades, they have not had too much influence of an innovative perspective that could lead to responses to the needs of the country, and to social and productive demands. Bolivia's trajectory on STI is relatively recent. The productive structure is reliant on technology-intensive imports and exports of raw materials with scarce highly skilled capabilities, migration of the skilled labor force and increasing problems in terms of programmatic continuity and long-term vision.

STI-oriented activities go back to the 1960s in Bolivia with the establishment of the National Academy of Science as the public institution in charge of scientific policies. In 1974, the Bolivian Institute of Agricultural Technology (IBTA) that would later be replaced by the Bolivian System of Agricultural Technology Transfer (2000), oriented to support the creation, development, validation, and transfer of agricultural technology to transform the agricultural productive system of the country. In 1977, the Ministry of Planning and Coordination became the organization in charge of STI promotion, and the National Council of Scientific and Technological Development (CONADECYT), as well as the Directorate of Science and Technology (DCYT), was established. The results, however, did not deliver the expected results, in part because, in reality, the support to this process was rather weak. It was in 1991 that the National System of Science and Technology (SNCT) got conceptualized as "the group of organizations, institutions, natural and jurisdictional persona dedicated to the management, implementation and application of scientific and technological activities, in particular the training of human resources, the research, development, information, advising,

engineering and use of knowledge." Between 1996 and 1997, the institutional consolidation of CONACYT through a set of short-term strategies aimed at solving some critical problems. In 1997, the first strategic policy was designed as well as a mid-term action plan known as "Innovation for Bolivia's competitiveness and sustainable development" ("Innovación para la Competitividad y el Desarrollo Sostenible de Bolivia"). When in 2001 the law to support STI got formulated, it helped the system and secretariat of STI (SENACITI) with which STI capacities were strengthened. Nonetheless, this law was never ruled and thus never really implemented.

Even though the first National Plan of STI was created in 2004 (2004–2009), it did not get approved or implemented due to the lack of funding. Two years later with a change in the political administration of Bolivia and the new presidency of Evo Morales, two main milestones took place: first, the creation of the Viceministry of S&T, and secondly, the design of the PND with a change in the concept of STI. That plan points out that "science and technology are fundamental instruments and tools for changing the primary-*export production pattern through the emergence of transformation processes of Bolivia's natural resources and the introduction of new products into the market.*" Simultaneously, it considers STI as a transversal platform for all the sectors of the development plan, and having an articulating role between the production of S&T, the local knowledge and ancestral know-how, and the demand (Supreme Decree Nº 29272 2007). In 2009, two other strategies added to this process of STI implementation: the Political Constitution of Bolivia, and the Sectoral Plan of S&T with a vision toward 2020, which has not yet been implemented.

In this context, in 2011 and with the engagement of the different STI stakeholders, the Pluri-annual Program of STI: First Phase (2012–2027) was set (analyzed in the next section) to fulfill the goals of the National Development Plan.

6.1.3 Peru

Peru's efforts toward STI go back to 1960. In 1968, the National Council of Research (CONI) was established to promote and lead the development of STI. It sought to structure the S&T System through the setting of a National Research Fund, which unfortunately did not work so well because of the resistance of some actors and the lack of private sector participation. During the 1970s, public research institutes were created and funded to support the productive sector. Some scattered good results coexisted with the general realization that impacts were not as expected in terms of economic, social, and environmental development. In 1981, it became the National Council of S&T with a new budget, but still these resources were not sufficient to strengthen the country's STI capabilities or reach a more efficient articulation with the private sector. Two years later, a set of S&T guidelines were established with short-, mid-, and long-term actions. Even if during the period 1985–1990, the allocated funds to CONCYTEC increased, the overall national budget to R&D continued to decrease. The larger amount of financial

resources for CONCYTEC did not lead to significant impacts on the country's development, in part because of a supply approach in which the knowledge and technology that was being produced did not contribute to the solution of needs and demands of the people, the government, or the productive sector. During the decade of 1990, STI activities were further damaged because of the ruling of structural adjustment policies and an authoritarian regime. Policies for the country's liberalization and openness to foreign capital weakened the endogenous capabilities of STI in Peru. CONCYTEC had a rather absence or presence in the government's decision-making.

In the early 2000, Peru begun its recovery from the political crisis and embraced some substantive changes in terms of the role and structure of the state, moving toward the idea of information and knowledge society, and a vision of integrative human development while recognizing the systemic character of competitiveness. The re-orientation of CONCYTEC was backed up by different public and private actors, and in 2002, it defined a National Emergency Plan to support STI in collaboration with different actors, including government, universities, and scientific institutions. In 2003, CONCYTEC created a commission to elaborate the First Plan of STI (PNCTI) and a proposal for a STI Law, which was approved in 2004, and seeks the articulation between the academia, firms, government, and society to respond to the economic, social, and cultural development of Peru. In parallel, CONCYTEC is asked to create, strengthen, and coordinate the National System of Science, Technology and Innovation (SINACYT) and emphasizes the interest on supporting the development, promotion, consolidation, transfer, and diffusion of STI as a public necessity. It also promotes the elaboration of others laws for the incentive and promotion of investments and taxes for STI activities, as well as the design of a pilot project of technological parks. It also pushes for the articulation of the STI plan with other strategic plans such as the one on competitiveness, regional plans, social development, and environmental sustainability.

In 2005–2006, the Strategic Plan of STI for the Competitiveness and Human Development was approved (PNCTI 2006–2021), which is analyzed in the next section.

6.1.4 Colombia

STI-related activities could be traced back to very old times in Colombia. However, the systematic building of an institutional setting goes back to the late 1960s. Three periods can be identified.[5] The first one is between 1968 and 1989, in which STI capacities were being developed, the training of human resources and the creation of research groups, moving research from an individual activity into an institutional one. The second period is during the 1990s with the promulgation of the S&T law, and the STI system. The third period is more of consolidation and

[5] For more information, see http://www.colciencias.gov.co/sobre_colciencias?vdt=info_portal|page_2.

could be placed in the year 2000 with a set of efforts oriented to the internationalization of knowledge (adoption of international standards), and the alignment of local capabilities with the economic and productive development of the country, and at the service of problems of health, environment, and education.

By 1968, the Colombian Institute for the development of Science and Technology "Francisco José de Caldas" (Colciencias) was created as a financing fund for science, in charge of coordinating, diffusing, and implementing programs and projects of scientific and technological development. In the 1980s, the institutional development was related to management and negotiation of technologies embodied in plants, equipment, and productive sector processes. During that same decade, by the mid-1980s, research groups became more visible and PhD programs began. In 1987, the idea of a ministry of S&T took over but it did not happen, and the ultimate choice was to have science more as a transversal institution with the engagement of all ministries and linked to the national budget. In 1988, the Mission of S&T was created with the goal of reorganizing the institutional environment and the elaboration of a normative framework for the development of STI in the country.

Based on that mission work, in 1990, a new law was created (#29) with a set of guidelines to establish the coordination of national investment on S&T; the bases for the National System of S&T (SNCyT) defined as a "*non-excluding open system that integrates all programs, strategies and activities of science and technology, independently of the institution (public or private) or the person who is in charge.*" The development of national programs implied a participatory planning, whose results led to a set of goals for the next few years. These results had to do with the need to increase the resources for S&T, more incentives to PhD programs, the strengthening of linkages between researchers and firms, and the consolidation of networks of knowledge, and robust scientific communities. Likewise, in 1991, regional commissions of S&T were established as a milestone in the process of building regional capabilities of STI (in spite of mixed results). The new National Constitution of that year made it compulsory for the government to support S&T, which contributed to the setting of a more coherent and long-term policy. During this phase, S&T become a key part of the economic policy and of the development plans. By 1995, the National Innovation System was defined based on a set of policies and guidelines oriented to: the support of productivity and competitiveness of firms, the introduction of new processes and products, technological adaptation, the training of the labor force, and the adoption of an entrepreneurial culture.

By the year 2000, some changes have taken place in the way science was being produced. It became a more multi- and trans-disciplinary endeavor, embedded in the social, cultural, and regional contexts and shaped by political decisions. It aimed at advancing the linkages between the scientific community and the institutional environment, and its appropriation by the productive sector and the Colombian society in general.

By 2006, Colombia faced the need to strengthen its capabilities to put knowledge at the service of its economic, social, and environmental development. In spite of the country's advances in STI, at that time, the situation was characterized

by: (1) low national investment on S&T in comparison to other countries in the region; (2) increasing scientific and technological capabilities but still far from international standards; (3) lack of legal mechanisms in the STI system; (4) lack of scientific and research vocation in the young population; (5) low appreciation of the importance of S&T activities, in general and by firms in particular; (6) low use of knowledge in the export-oriented economic and productive activity; (7) weak linkages between firms and universities; and (8) increasing the appropriation and promotion of research and technological development. By the end of 2006, the National Plan for STI development (2007–2019) was introduced. Two years later, Colciencias introduced a proposal for a development strategy based on scientific and technological knowledge known as "Colombia Construye y Siembra Futuro. Política Nacional de Fomento a la investigación y la innovación." By 2009, the legal framework on STI was changed with the law 1286, which turned Colciencias into an administrative department, and the overall STI system got strengthened.[6] This plan as well as the ones from Bolivia, Ecuador, and Peru is analyzed in the following section.

6.2 Current Paradigms in STI Policy and Their Relationship with (Inclusive) Development

As was discussed in the previous section on the evolution of STI in the four countries, the relative advancement and the situation of each one in terms of STI has been rather diverse, both in terms of their S&T capabilities as well as in their level of maturity and consolidation of the National Systems of STI. Colombia could be placed as a country with a remarkable trajectory that somehow departs from the other three. The concerns and challenges are different for these countries, as their strategies are. In any case and from a general standpoint, there are some shared weaknesses: lack or inadequacy of skilled human resources for S&T, lack of economic resources, weak or disarticulated national STI systems, lack of infrastructure for S&T, institutional and political rigidities, weak production, use and application of knowledge to solve problems either of the productive, societal or environmental sector.

Furthermore, the status of these plans and their level of maturity is also different. While in Ecuador and Bolivia, the plans are being developed and designed given the recent political changes in those countries, Colombia and Peru have had more time in their implementation, even though these plans are still being concerted. They share, however, the concern on STI as an instrument to reach inclusive development, from an economic, social, and environmental perspective. The four countries place STI as an instrument capable of stimulating and favor the

[6] For more information, see http://www.secretariasenado.gov.co/senado/basedoc/ley/2009/ley_1286_2009.html, last accessed 1 April 2013.

expansion of (economic, political, and social) opportunities and thus strengthen the capabilities for human and institutional learning.

They conceive knowledge and learning as a mechanism for the productive and social transformation of their countries, leading to sustained economic growth on one hand, and environmentally sustainable on the other, through the increase in the productivity that comes from knowledge-based value, and as a tool that allows for the expansion of opportunities and capabilities of people to have a life in plenitude and decide over their own future, since STI is seen as a means to overcome different types of social, political, economic exclusion/deprivations.

Bolivia and Ecuador might embrace the more radical perspectives, fist because they point out the need to have STI policies that contribute to the national development goals as part of a change strategy and of an endogenous approach to the needs and capabilities. Secondly, because the rationale of the STI policy is centered on the productive transformation of the country based on the principles of solidarity, sustainability, participation, and democracy, looking for the building of plurinational and democratic states that envision knowledge and information as public goods, and as a right of and for the people. Likewise, they seek to have state policies for developing STI as a basis for the structuring of an inclusive scientific culture that includes scientific and technological knowledge as well as local and ancestral knowledge for the production of goods and services. Thirdly, because the values behind these countries' STI paradigm is linked to the democratization of STI, the traditional knowledge, and ancestral know-how as they explicitly seek to contribute to well-being and place an equal dialogue between these different types of knowledge as a precondition. The perspective is thus based on solidarity, responsibility, participation, integration, and inclusion, without dismissing quality and excellence, and the concern on equity of income, gender, culture, race, and geography.

Even if in the cases of Colombia and Peru, there is an alignment between the STI policy objectives and those of a broader development strategy, it is a more moderate alignment and change is not so radical. Colombia does justify its STI policy based on the need to transform the societal and productive structures and highlights the importance of a change in the specialization pattern, of improving drastically (quantitatively and qualitatively) its scientific and technological capabilities, while also planning on the concert and coordination of policies to sustain the collective effort in the long term. It also values STI development as a sociocultural and cumulative process of building human and institutional capabilities (generation, assimilation, adaptation, social appropriation and application of knowledge) as an instrument for the expansion of freedoms, that is, for social and economic development. The political paradigm of STI refers to STI as an instrument for development, understood as commercial competitiveness at the global level, but also as a process of improving quality of life of the people, the efficient and sustainable use of natural and geopolitical resources, and the validity of a social state of rights and the respect of human rights, likewise the tackling of critical problems of Colombia such as violence, poverty, social exclusion, and the resolution of social and political conflicts.

In the case of Peru, the shift in the STI approach has not been so drastic and still keeps some catching-up type of strategies, while emphasizing innovation as a source of firm competitiveness, IPRs, incentives for research, and the training of human resources for scientific and technological research. It does mention the need to foster applied research, and the transfer of its results for social and sustainable development, and the research orientation for the rescue and value of traditional knowledge, but more from a top-down perspective. Peru's approach is connected to the focus on university–firm linkages, a demand perspective, the development of comparative advantages and leadership, the promotion of human development and environmental sustainability.

An important feature in relation to the feasibility, legitimation, and implementation of the different plans, and in particular, if they relate to social inclusion, is the process itself. That is, plans oriented to tackle social inclusion need to be consultative and lead to participation and engagement. So questions such as what were the foundations of the plans, how were they conceived and agreed upon, and with whom, in the different phases of the policy cycle have become fundamental. However, as was mentioned before, the short time span behind these plans makes it impossible to analyze them thoroughly along the whole policy cycle. We will only concentrate on the design phase, and the next section focuses on the following questions: (1) how/what is the process of the problem definition?; (2) who defines these problems?; (3) what are the alternatives/solutions for approaching these problems?, do these alternatives respond to local/national demands and to an endogenous vision of development, or do they emerge based on external factors (such as international donor recommendations)?; (4) based on the previous point, what are the limits and scope of the STI policy; and (5) to what extent do STI policies interact with other policies?

In sum, as indicated in the previous paragraphs, the current STI plans of Bolivia, Colombia, Ecuador, and Peru share the placement of STI as a means, as a vector for development. They vary in their emphases, scope, their points of departure and level of maturity, among others, but in all cases, STI is not an end in itself but a vehicle for development. The next section elaborates around the processes through which the plans have emerged. There has also been a relatively common thrive on consultation and participatory processes for elaborating these plans. The details are discussed in the following paragraphs.

6.3 STI Policy Design and Participation: Developing Institutional Capabilities

Throughout the set of analyzed cases, the methodology for designing the plans relied on active participatory processes of the stakeholders of the National Systems of STI. However, the level of institutionalization and strategic, programmatic, and operational planning varied quite substantially across the countries. Colombia might be the country with a more defined, structured and

institutionalized agenda, followed by Bolivia, Ecuador, and Peru, which seem to have had some difficulties in articulating and promoting a wider participation.

A synthesis of the different phases undergone throughout the plans' design shows that in all cases, there was a process of systematization of primary information, through workshops, interviews, consultations, and the use of ICTs, complemented by secondary information from the analysis of documents, indicators, and studies. The goal was always to identify and contribute to a diagnosis to define the objectives, scope, actions, programs, and instruments.

In Ecuador and Bolivia, several workshops and socialization instances were carried out in different regions to better understand the needs, demands and local capabilities, and their articulation into the sectoral and territorial policies at the national level. Networks of researchers, policy managers, and the ones who represented the voice of the traditional knowledge and ancestral know-how came together to participate in the discussion, proposition, and dissemination of the policy process. This participatory and integrative process in turn attempted to systematically articulate and coordinate the STI policies in the planning and development programs of these countries, while spatially and temporally aligning and coordinating the objectives. Bolivia and Ecuador have adopted an endogenous approach which is respectful to the cultural and knowledge diversity, and one that integrates the different capacities in STI, types of knowledge, and know-how located through the territory in a way that promotes synergy, coordination, cooperation, and solidarity to reach the national and local development goals.

In Colombia, the plan is conceived as a cooperative, concerted, and coordinated endeavor of all the STI system actors. It focuses around three coordination agendas: one is the interministerial and other national agencies, through concerted policies and a unified action led by the National Department of Planning (DNP); the second is the interinstitutional; and the third one relates to the territorial coordination. Colciencias in turn is the actor that promotes and coordinates this process, though for these coordination mechanisms to be efficient, they require government prioritization as well as political and instructional support. The strategic planning that defines the vision, mission, plan, and general objectives is defined from a macro- and long-term perspective; then from a meso- and mid-term perspective, the programmatic planning with the sectoral and regional vision, the programs, the purpose and the goals are defined; and finally, the operational and short-term perspectives are used to define the local vision and the projects that are to be implemented.

In spite of Peru's attempt to develop its diagnosis and STI policies, programs and projects based on a participatory and consultative process, the actual setting of regional STI networks has been weak due to the incipient level of regionalization and linkages between STI institutions, as well as the lack of public and private funding. Yet, with these limitations, CONCYTEC has been able to promote regional coordination in 12 regions of Peru, as well as a debate and the emergence of proposals with representatives of the regional institutions, the productive sector, the academic community, and the civil society. In some regions, it has created consultative councils of STI as managerial units attached to regional governments.

In sum, in Bolivia, Colombia, Ecuador, and Peru, the diagnoses and identification of pressing problems have been in alignment to the national, regional, and/or sectoral needs. In particular, there has been a specific concern on the reorientation of STI, the traditional knowledge, and know-how toward the search of solutions to national and local problems, both at the production level as well as socially and environmentally.

The experience of the four countries indicates that the design of an integrative STI policy approach is largely complex, as it relies on the relationship with macro-, meso-, and micro-level policies that go from the national, to the regional and sectoral levels, together with the long, mid, and short-term. As it has been put forward, the different countries have followed different strategies and rely on different levels of institutional development. The more advanced in interinstitutional coordination for the development of their plans are Colombia and Bolivia where the various ministries, including education, development, planning, economy, finance, agriculture, and industry, have been working in relation to regional and local governments, and with other actors of the STI system.

The next table summarily illustrates the analysis of the STI plans in the four countries, based on the following dimensions (Table 3):

- Triggers for policy change
- Policy rationale
- Core values
- Policy design: methods and phases
- General and specific objectives
- Policy boundaries/domains
- Policy actors.

7 Final Remarks

This chapter stresses the relevance of studying STI policies and policy frameworks and their connection to inclusive development. We analyzed the current STI plans of Bolivia, Colombia, Ecuador, and Peru, and how STI policy is framed and is connected to the broader discussion on STI for inclusive development. Framing STI as a vector for development, one that goes beyond the economic development and competitiveness rationale, is today not only an analytical concern but also an empirical exploration. Nowadays, the realization that STI matters for economic growth and requires explicit policies is extensively accepted and legitimized in developing countries. But some developing countries are further concerned with tightening the connection of STI with broader development processes and problems such as social inclusion, poverty, and inequality.

These shifts in STI policy frameworks are currently taking place, and in most South American cases, they are still in the planning phases, which make it difficult to reach solid conclusions, and more time is needed to assess them in terms of

Table 3 Learning from Bolivia, Colombia, Ecuador, and Peru STI plans: how much inclusion and development?

	Ecuador	Bolivia	Peru	Colombia
Program name	National plan of science, technology, innovation and knowledge for good living 2009–2015	Pluri-annual Program of science, technology, and innovation 2012–2027	Strategic national plan of science, technology, and innovation for competitiveness and human development (PNCTI) 2006–2021	National plan of scientific, technological, and innovation development 2007–2019
Triggers for policy change	Weakness of STI (human resources, infrastructure, and economic resources)	Weakness of STI (human resources, infrastructure, and economic resources)	Weakness of STI (human resources, infrastructure, and economic resources)	Weakness of STI (human resources, infrastructure, and economic resources)
	Weak articulation of NIS, both institutionally and politically	Weak articulation of NIS, both institutionally and politically	Weak articulation of NIS, both institutionally and politically	Weak articulation of NIS, both institutionally and politically
	Weak demand of knowledge			Weak demand for knowledge
Policy rationale	STI and (ancestral) knowledge for transforming the productive structure into a more solidary, sustainable and democratic system, for the construction of a plurinational and democratic state; for environmental sustainability	STI for the solution of local/national problems STI + local knowledge + ancestral knowledge that serves for the production of goods and services Setting of state policies for the development of science and technology for a scientific and inclusive scientific culture	STI for business competitiveness, social development and environmental sustainability STI transfer and technological adaptation, linkages, and associativity, IPR, research incentives Revalorization and use of traditional knowledge Stimuli to the building of STI capabilities	STI for productive and social transformation Promote a coordination of public policies to finance and support a collective long-term effort
	International linkages		International linkages	
	Knowledge and information as public goods (and democratic means)			

(continued)

Table 3 (continued)

	Ecuador	Bolivia	Peru	Colombia
Core values	• Democratization of STIK platform STI as means for fostering good living Value of human and territorial capabilities Equalitarian dialogue between knowledge and (ancestral) knowledge Rights guarantee of individuals, communities, and nature Shared vision and creation of a critical mass for good living; Intergenerational justice; solidarity strategic alliances, both national and internationally.	Articulating, integrative and proactive Self-critical, innovator, flexible and internalizing Cooperative, linking, competitive and quality-based Participative, responsible, solidary and harmonious Sustainable, transparent and long term Normative-institutional consistency Income, gender, cultural, race, and geographic equality Respect for the historic, scientific, and innovation processes	Demand-driven approach and human development Academy-firm linkages Comparative advantages and leadership Environmental sustainability	STI as a sociocultural and cumulative process of human and institutional capacity building to generate, assimilate, improve, adapt, socially appropriate, and apply knowledge in the social and economic development and in the national training for global economic competitiveness

(continued)

Table 3 (continued)

	Ecuador	Bolivia	Peru	Colombia
Policy design process—methods and phases	(1) Integration and diagnose (2) Policy, program and project definition (3) Approval of sectoral policy and incorporation into the national system of planning Participatory process and consultation with key actors	(1) Planning and methodological design (2) Information treatment and analysis (3) Knowledge co-management (4) Formulation of the STI pluriannual program Participatory process and consultation with key actors	(1) Integration and diagnose (2) Information treatment and analysis (3) Policy, program, and project definition Participatory process and consultation with key actors	(1) Strategic planning: vision; mission; planning; general objective (long term and macro) (2) Programmatic planning: sectoral-regional vision; program; purpose; goals (midterm and meso) (3) Operational planning: local vision; project (short term and micro) Participative process and consultation with key actors
General objectives	Accelerate the transformation of accumulation patterns and (re)distribution of wealth for good living, through the National Systems of STI and (ancestral) knowledge	To support the emergence of a scientific–technological cultures across all societal levels, through the diffusion and popularization of ST knowledge contribute to the productive transformation of the country through the activation and impulse of the system systematize, register, and protect the native and peasant knowledge for their inclusion in the new productive structure	To assure the articulation between the STI system actors, focusing their efforts to respond to technological demands in strategic prioritized areas, with the goal of strengthening the value added, improve the population quality of life, and contribute to a responsible management of the environment	Produce, diffuse and use knowledge to contribute to productive and social transformation of the country to guarantee improved competitiveness and sustainable human development; Improve scientific, technological and innovation development of Colombia

(continued)

Table 3 (continued)

	Ecuador	Bolivia	Peru	Colombia
Specific objectives	(1) Consolidate the STIK institutional environment and (2) foster the appropriation and democratization of (ancestral) knowledge for improving quality of life and equality rights (3) Strengthen innovation for accelerating democratic productive transformation, and (4) integrate STIK for environmental sustainability	(1) To foster and development of research processes that contribute to the understanding of local and regional contexts (2) To foster and consolidation of the knowledge production for the solution of local/national problems (3) To set state policies for the development of science and technology for a scientific and inclusive scientific culture (4) To develop science, technology, and innovation so that the scientific-technological knowledge and the local and ancestral knowledge is used to solve the production of goods and services	i) To promote the development and transfer of technological innovation in firms, increasing their productive competitiveness, and the value added with the criteria of economic and environmental sustainability (2) To foster scientific and technological research oriented to the solution of problems and to the fulfillment of demands in the strategic prioritized areas (3) To Improve, quantitative and qualitatively the human capabilities in STI, with an emphasis in the excellence training at the postgraduate level, and in the technical area (4) To strengthen, invigorate, and synergistically articulate the STI institutions in the context of the National System of Strategic Planning	(1) To improve innovation and productive development; (2) To increase knowledge production (3) To foster ST + I appropriation in Colombian society (4) To increase and strengthen human capabilities for ST + I (5) To consolidate the institutional level of the national STI system (6) To consolidate infrastructure and information systems for ST + I (7) To promote regional integration (8) To consolidate the internationalization of STI
Policy boundaries/ domains	Long-term policies; Sectoral and territorial, adjusted to local needs and capabilities, and in coordination with the national policies and their objectives	Long-term policies; Sectoral and territorial, adjusted to local needs and capabilities, and in coordination with the national policies and their objectives	Long-term policies; Sectoral and territorial, adjusted to local needs and capabilities, and in coordination with the national policies and their objectives	Structural propose, national scope, multidimensional, and multisectoral nature (long and midterm)

(continued)

Table 3 (continued)

	Ecuador	Bolivia	Peru	Colombia
Types of instruments	Oriented at the training of human resources (at all levels) Oriented to system development, articulation, and coordination (networks, institutional change) Oriented to the revalorization of STI and (different types of) knowledge	Oriented at the training of human resources (at all levels) Oriented to the revalorization of STI and (different types of) knowledge on the productive processes Oriented to system development, articulation, and coordination (networks, institutional change) Strengthening the innovation fund; training support of innovation managers; development of foresight in technological strategies; fund attraction program Oriented to social appropriation of S&T Articulation and strengthening of national, local, municipal, and regional initiatives with the current and future strategic platforms Development of scientific and technological research of the current and future resources	National/sectoral STI programs (Agriculture, medicinal plants, forestry, animal breeding, fishing, education, health, mining, transport, tourism, aquiculture) National transversal programs (basic research, biodiversity, biotechnology, materials, environmental, hydric resources, information technologies, energy) Regional programs of STI, articulated with the national programs (sectoral and transversal) and the special ones for supporting STI Special programs (human resources training, system development, and articulation, research funding, transfer, vigilance, cooperation, popularization of science)	Fundamental research program (energy and matter; biological processes, agro food and biodiversity; human being and the environment; education, culture, and institutions; knowledge management, social applications, and technological convergence) University-productive sector linkages program (institutional/organizational development, technological development; technology transfer) Venture capital program; Social innovation, organizational, and entrepreneurship program Program of ST + I presence in the public agenda Oriented to human resource training Oriented to the development, articulation and coordination of the system Program of appropriation and use of IP system Foresight program of science, technology, and competitive intelligence Oriented to infrastructure development and diffusion of knowledge Program of empirical and traditional knowledge communities Program of articulation of Colombia to strategic bilateral and multilateral programs of ST + I of international cooperation

(continued)

Table 3 (continued)

	Ecuador	Bolivia	Peru	Colombia
Policy actors	SENESCYT (National Secretariat of Higher Education, Science, Technology and Innovation) SENPLADES (National Secretariat of Planning and Development) Higher Education Institutions and Research institutes Regional governments Representatives of ancestral knowledge	Vice-presidency Education Ministry and vice-ministries Culture ministry Rural and Land Development Ministry Development planning Ministry Production and Plural Economy Ministry Economy and Finances Ministry Local, municipal and native governments Directorates and research units Public and private universities Productive organizations Private and public enterprises	Education Ministry Regional governments CEPLAN (National center of strategic planning) CONCYTEC (S&T Council)	Ministries and national, regional, and local organizations related to STI Actors of the public and private academic sector and of the National System of STI (SNCT + I)

The original title in Spanish refers to "Saberes," which entails a different notion, compared to knowledge. Saberes is about ancestral knowledge

outputs and outcomes on a systematic basis. But at least in terms of their intentions and the processes through which these plans are designed and established, they commonly rely on consultative and participatory processes. Deliberation and participation seem to be crucial for building capabilities and expanding the choices about STI policies for development goals.

Expanding the deliberative and participation process is one very relevant mechanism in the search for more inclusive innovation and development. It might not be sufficient if not complemented with other inclusive mechanisms, strategies, instruments, as well as explicit goals. Including the more vulnerable populations in the decision-making, deliberation, and design could be not only a mechanism for getting the voice of those that are often silenced, but also to expand and strengthen their agency and learning capabilities. These experiences also evidence their embeddedness in local contexts, needs, and capabilities. Rather than institutional mono-cropping, the analyzed cases illustrate processes in search of endogenous development strategies. STI appears as an instrument for economic growth and the well-being of society, leaving behind the idea of development as catching-up.

Strong commonalities between these countries' plans coexist with some differences and specificities, not only in terms of their goals, approaches, and scope, but also related to the institutional and political contexts in which they are embedded. In the four countries, the diagnoses and identification of pressing problems have been in alignment with the national, regional, and/or sectoral needs. In particular, there has been a specific concern on the reorientation of STI, the traditional knowledge, and know-how toward the search of solutions for national and local problems, both at the production level as well as socially and environmentally.

In spite of the limitations imposed by the analysis of plans that have not yet been fully implemented, they indicate the concern on the articulation of the STI policy with other policy domains (industry, agriculture, education, social, and environment). The experience of the four countries indicates that the design of an integrative STI policy approach is largely complex, as it relies on the relationship between macro-, meso-, and micro-level policies that go from the national, to the regional and sectoral levels, together with the long, mid, and short-term. The different countries have followed different strategies and rely on different levels of institutional development. Colombia and Bolivia have had the more advanced interinstitutional coordination for the development of their plans, where the ministries of education, development, planning, economy, finance, agriculture, and industry have been working in relation to regional and local governments, and to other actors of the STI system.

The newness of these plans and the still open definition of specific instruments in some cases make it difficult to state the extent to which they fit one or another of the analytical approaches connecting innovation and social inclusion that were discussed above, or to determine whether they might lead to new theoretical insights linking STI with inclusive development. These remain as open questions that call for a close monitoring and follow-up of the implementation of these plans and experiences.

References

Abramovitz M (1956) Resource and output trends in the United States since 1870. Am Econ Rev 46(2):5–23

Abramovitz M (1986) Catching Up, Forging Ahead, and Falling Behind. J Econ Hist 46(2):385–406

Ali L, Hyun SH (2007) Measuring inclusive growth. Asian Devel Rev 24(1):11–31

Ali L, Zhuang JZ (2007) Inclusive growth toward a prosperous Asia: Policy implications. ERD Working Paper Series 97

Alzugaray S et al (2011) Building Bridges: Social inclusion problems as research and innovation issues. Paper presented at the Globelics Conference, Buenos Aires

Alzugaray S et al (2011) La investigación científica contribuyendo a la inclusión social. Revista CTS 6(17):11–30

Arocena R, Sutz J (2009) Sistemas de innovación e inclusión social. Universidad de la República, Uruguay. Pensamiento Iberoamericano, segunda época 2009/2(5). http://www.pensamientoiberoamericano.org/articulos/5/117/110/sistemas-de-innovacion-e-inclusion-social.html. Accessed Jul 2012

Benyacar A et al (2008) Commercializing an Innovation in an Invisible Market: Case of Ecosan toilets

Bianco M et al (2010) Investigación orientada a la inclusión social: complejidades y desafíos para el contrato social de la ciencia en contextos de subdesarrollo. Paper presented at the VIII Jornada ESOCITE, Buenos Aires

Bound J, Johnson G (1982) Changes in the structure of Wages in the 1980s: An evaluation of alternative explanations. Am Econ Rev 82:371–392

Card D, Dinardo JE (2002) Skill-biased technological change and rising wage inequality: Some problems and puzzles. NBER Working Papers 8769

Economic Commission for Latin America and the Caribbean (2011) Panorama social de la América Latina. ECLAC

Chataway J, Smith J (2006) The International AIDS Vaccine Initiative (IAVI): Is it getting new science and technology to the world's neglected majority? World Development 34:16–30

Cozzens S, Sutz J (2012) Innovation in Informal Settings: A Research Agenda. IDRC

Cozzens SE et al (2006) Distributional Assessment of Emerging Technologies: A framework for analysis. ResIST Project—James Martin Institute Working Paper 1

Dagnino R (ed) (2010) Tecnologia social: ferramenta para construir outra sociedade. Unicamp, Instituto de Geociencias, Campinas

Departamento Administrativo de Ciencia, T. e I. (2011) Informe al Congreso de la República. Agosto 2010—Julio 2011. COLCIENCIAS, Bogota

Emmerij L (ed) (1997) Economic and social development into the XXI century. IDB, Washington DC

Evans P (2004) Development as Institutional Change: The Pitfalls of Monocropping and the Potentials of Deliberation. Stud Comp Int Dev 38(4):30–52

Fajnzylber F (1989) Industrialización en América Latina: de la 'caja negra' al 'casillero vacío': comparación de patrones contemporáneos de industrialización. Cuadernos de la CEPAL 60. ECLAC

Fressoli M et al (2011) From Appropriate to Social technologies: some enduring dilemmas in grassroots innovation movements for socially just futures. GLOBELICS, Buenos Aires

Galor O, Tsiddon D (1997) Technological progress, mobility and economic growth. Am Econ Rev 87:363–382

Gras N (2012) Innovación orientada a la inclusión social: un modelo basado en agentes. Maestría en Economía y Gestión de la Innovación, Universidad Autónoma Metropolitana

Gupta AK (2000) Grassroots Innovations for Survival. ILEIA Newsletter 2(16)

Gupta AK (2007) Towards an inclusive innovation model for sustainable development, paper presented at the Global Business Policy Council, A. T. Kearney-CEO's Retreat, Dubai, December

Hart SL (2005) Capitalism at the Crossroad: The Unlimited Business Opportunities in Solving the World's Most Difficult Problems, Upper Saddle River, Wharton School

Heidenheimer AJ et al (1990) Comparative Public Policy: The Politics of Social Choice in America, Europe and Japan. St Martin's Press, New York
Hirschman AO (1986) Enfoques alternativos sobre la sociedad de mercado y otros ensayos recientes, Ciudad de México, FCE-Economía Contemporánea
Inter-American Development Bank (2011) The Imperative of Innovation: Creating Prosperity in Latin America and the Caribbean. IDB, Washington DC
International Development Research Centre (2011) Innovation for Inclusive Development: Program Prospectus for 2011–2016. IDRC, Ottawa
Iizuka M, Sadre Ghazi S (2011) Understanding dynamics of pro-poor innovation: Mapping the disputed areas. Paper presented at the DIME Final Conference, Maastricht
Infante R, Sunkel O (2009) Chile: towards inclusive development. ECLAC Review 197:135–154
Jiang Y (2011) Methods to reduce transaction costs and to establish low transaction cost environments for inclusive development, Paper presented at the Globelics Conference, Buenos Aires
Juhn C et al (1991) Accounting for the Slowdown in Black-White Wage Convergence. In: Kostes, MH (ed) Workers and Their Wages: Changing Patterns in the United States. AEI Press, Washington DC
Kaplinksy R (2011) Schumacher meets Schumpeter: Appropriate technology below the radar. Res Policy 40(2):193–203
Kaplinsky R et al (2010) Below the radar: what does innovation in emerging economies have to offer other low-income economies? Int J Tech Manag Sustain Dev 8(3):177–197
Katz J (2006) Cambio estructural y capacidad tecnológica local. ECLAC Review 89:59–73. ECLAC
Klasen S (2010) Measuring and Monitoring Inclusive Growth: Multiple Definitions, Open Questions, and Some Constructive Proposals. ADB Sustainable Development Working Paper Series 12, Manila
Lazonick W (1998) Organizational Learning and International Competition: The Skill-Base Hypothesis. In: Michie J, Grieve Smith J (eds) Globalization, Growth and Governance: Creating an Innovative Economy. Oxford University Press, London
Lundvall B-A (1996) The Social Dimension of the Learning Economy. DRUID, Aalborg
Prahalad CK (2005) The Fortune at the Bottom of the Pyramid: Eradicating Poverty through Profits. Enabling Dignity and Choice Through Markets. Wharton School Publications, Upper Saddle River
Prahalad CK, Hart SL (2002) The Fortune at the Bottom of the Pyramid. Strategy+Business 26:54–67
Raina RS (2011) But why? A policy for agricultural science in India. Paper presented at the Atlanta Conference on Science, Technology and Innovation Capacities, Atlanta
Ramani S (2008) Playing in Invisible Markets: Toilet Innovations and Empowerment. Charles Cooper Memorial Lecture, Working Paper. UNU-MERIT, Maastricht
Ramani S et al (2010) On the Delivery of Pro-Poor Innovations: Managerial Lessons from Sanitation Activists in India. Working Paper series 2010-018. UNU-MERIT, Maastricht
Sagasti F (2011) Ciencia, Tecnología, Innovación: Políticas para América Latina. Fondo de Cultura Económica, Lima/Mexico
Saint-Paul G (2008) Innovation and Inequality: how does technical progress affect workers? Princeton University Press, Princeton
Schumacher EF (1973) Small Is Beautiful: Economics as if People Mattered. London, Blond & Briggs Ltd
Schumpeter JA (1934) The Theory of Economic Development. Harvard University Press, Cambridge
Sen A (1983) Development: Which Way Now? Econ J 93:745–762
Sen A (1987) The Standard of Living: Lecture II, Lives and Capabilities. In: Hawthorn G (ed) The Standard of Living. Cambridge University Press, New York
Sen A (1999) Development As Freedom. Anchor Books, New York
Solow R (1956) A Contribution to the Theory of Economic Growth. Q J Econ 70(1):65–94

Sutz J (2008) Ciencia, Tecnología, Innovación e Inclusión Social: Una agenda urgente para universidades y políticas. In: Ciencia, tecnología y sociedad. Centro Cultural de España, Montevideo
UNDP (1990) Concept and Measurement of Human Development. UNDP, New York
UNDP (1992) Global Dimensions of Human Development. UNDP, New York
UNDP (1993) People's participation. UNDP, New York
UNDP (2008) Creating Value for All: Strategies for Doing Business with the Poor. UNDP, New York. http://www.growinginclusivemarkets.org/. Accessed Mar 2012

Bolivia

Decreto Supremo Nº 29272 Evo Morales Ayma Presidente Constitucional de la República
Plan Nacional de Desarrollo: "Bolivia Digna, Soberana, Productiva y Democrática para Vivir Bien". Lineamientos Estratégicos 2006–2011, La Paz, Sept 2007. http://www.cienciaytecnologia.gob.bo/vcyt2012/uploads/boliviaplan_desarrollo_nac_ds_29272.pdf
Santivañez Galarza JL, Fernández Osinaga P (2011) Programa plurianual de ciencia, tecnología e innovación: Primera Fase 2012–2027. Documento Fase 1. Ministerio de Educación, La Paz

Colombia

COLCIENCIAS (2006) Plan de Desarrollo Científico, Tecnológico y de Innovación 2007–2019. COLCIENCIAS/DNP, Bogotá
COLCIENCIAS (2008) Colombia Construye y Siembra Futuro. Política Nacional de Fomento a la Investigación y la Innovación
Antecedentes de la evolución de la política de CTI en Colombia. http://www.colciencias.gov.co/sites/default/files/recursos/documentos/colombiaconstruyesiembrafuturo20082011.pdf

Ecuador

SENESCYT, SENPLADES (2011) Diseño Participativo del Plan Nacional de Ciencia, Tecnología, Innovación y Saberes para el Buen Vivir.
http://www.somosciencia.gob.ec/
http://plan.senplades.gob.ec/inicio
http://www.senescyt.gob.ec/web/10156/348

Peru

Plan Nacional Estratégico de Ciencia, Tecnología e Innovación para la Competitividad y el Desarrollo Humano PNCTI 2006–2021. http://www.minedu.gob.pe/normatividad/reglamentos/PlanNacionalCTI-CDH2006-2021.php 944