

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

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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 both⁴; 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 were 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 such 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 sectorized, 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
<i>Federal expenditure in science and technology</i>	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)

^aThe 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
<i>Program or fund</i>	%	%	%	%
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
<i>Sectorial funds</i>	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

^aIncludes CONACYT-SENER-Hydrocarbons; CONACYT-Ministry of Energy-Energetic Sustainability; Sectorial Fund for Energy (CONACYT-CFE); ^bTechnological Innovation Fund of CONACYT-Ministry of Economics; Sectorial Fund for Innovation (FINNOVA); ^cIncludes 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 Inter-sectoral Budget Committee and the Inter-sectoral 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.

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