

**COMMUNICATION CHANNELS AMONG THE ACTORS
OF THE COLOMBIAN SYSTEM OF SCIENCE,
TECHNOLOGY AND INNOVATION: A TEST OF THE
SABATO'S TRIANGLE MODEL**

by

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ABSTRACT

Colombia has a solid and stable National System of Science and Technology (SNCyT, by its acronym in Spanish), despite few researchers and innovators, and a small and instable public budget for research and innovation. The national agency, Colciencias, was created in 1968 and the system was created by law in 1991. The SNCyT is conceived as an open non-exclusionary space, composed by various programmes, agents, and activities.

The system is organized in three levels: national, regional, and sectoral and there are councils at each level where the coordination of policies should happen. All bodies are collegiate based on Sábato's Triangle, where three groups of actors (government, academia and industry), properly articulated should be able to define strategy in science and technology (S&T).

The main objective is to analyze the impact of Sábato's Triangle on the development of the Colombian SNCyT, using sociological and communication perspectives. The Councils of the National Programmes of S&T are the heart, where the management of S&T activities occurs. One specific objective is to explain the role that these councils have played in governing S&T.

Two main inquiry instruments are used: a survey to study the perceptions of the councillors about their role, and interviews of Colciencias officials to evaluate the system and determine policy successes and failures. Systems are composed basically of elements and relations among them. The Triple Helix and Sábato's Triangle models state that interactions are key. Therefore, the existence of a system is determined if actors interact, as in a network. In the development of these relationships, institutions are recognized and legitimized, or not. The final result will be expressed in the construction of social capital.

There are two main findings: firstly, the legal framework has contributed to create an institution, SNCyT, although institutions are socially produced so the issue is legitimacy. Secondly, two elements have contributed to making social

capital work: the information and power used by councillors, as well as the existence of committed councillors, who despite Colciencias not promoting the effective functioning of the councils, make the SNCyT works.

Keywords: Colombia; governance of science and technology; Triple Helix model; research councils; innovation systems

DEDICATION

To my father René (R.I.P), and my mother Angela,
who gave me life and moral principles, and
always supported me to study and become a better person.

To God, who placed obstacles on my journey, but gave me strength
and loving and supporting relatives and friends.

As a breast cancer survivor,
I have a second chance to live in full command of my life.

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ACRONYMS

Bancoldex	<i>Banco de Comercio Exterior de Colombia</i> (Colombian foreign trade bank)
CENICAFE	<i>Centro Nacional de Investigaciones del Café</i> (Colombian coffee research centre)
Codecyt	<i>Consejo Departamental de Ciencia y Tecnología</i> (Departmental (subnational) council of science and technology)
CNCyT	<i>Consejo Nacional de Ciencia y Tecnología</i> (National council of science and technology)
CONPES	<i>Consejo Nacional de Política Económica y Social</i> (National council of economic and social policy)
CPNCyT	<i>Consejo de Programa Nacional de Ciencia y Tecnología</i> (Council of national programme of science and technology)
DNP	<i>Departamento Nacional de Planeación</i> (National planning department)
FNG	<i>Fondo Nacional de Garantías</i> (National fund for guarantees)
IADB	Inter-American Development Bank
IAN	<i>Instituto de Asuntos Nucleares</i> (Nuclear affairs institute)
ICA	<i>Instituto Colombiano Agropecuario</i> (Colombian agricultural institute)
ICETEX	<i>Instituto Colombiano de Crédito y Estudios Técnicos en el Exterior</i> (Colombian fund for international studies and technical training)
IDRC	International Development Research Centre
IFI	<i>Instituto de Fomento Industrial</i> (National industrial promotion fund)
IIT	<i>Instituto de Investigaciones Tecnológicas</i> (Technological research institute)
INS	<i>Instituto Nacional de Salud</i> (National institute of health)

NSI	National System(s) of Innovation
OAS	Organization of American States
OCyT	<i>Observatorio Colombiano de Ciencia y Tecnología</i> (Colombian observatory of science and technology)
OECD	Organization of Economic Cooperation and Development
P-A	Principal – Agent
PNCyT	<i>Programa Nacional de Ciencia y Tecnología</i> (National programme of Science and Technology)
Proexport	<i>Fondo de Promoción de Exportaciones</i> (National fund for export promotion)
Redalyc	<i>Red de Revistas Científicas de América Latina, el Caribe, España y Portugal</i> (Network of academic journals of Latin America, the Caribbean, Spain and Portugal)
RICyT	<i>Red Ibero e Interamericana de Ciencia y Tecnología</i> (Ibero and Inter American network of science and technology indicators)
SciELO	Scientific Electronic Library Online
SENA	<i>Servicio Nacional de Aprendizaje</i> (Colombian technical training agency)
SNCTI	<i>Sistema Nacional de Ciencia, Tecnología e Innovación</i> (Colombian national system of science, technology and innovation)
SNCyT	<i>Sistema Nacional de Ciencia y Tecnología</i> (Colombian national system of science and technology)
SCI	Science Citation Index
SSCI	Social Science Citation Index
SSS&T	Social studies of science and technology
STI	Science, technology and innovation
STP	Science and technology policy

S&T Science and technology

UNESCO United Nations Educational, Scientific and Cultural Organization

INTRODUCTION

The creation of the Colombian Fund for Scientific Investigation and Special Projects, Colciencias, in the late 1960s was a response to regional and multilateral initiatives promoted mainly by the Organization of American States (OAS) and the United Nations Educational, Scientific and Cultural Organization (UNESCO). Colciencias has since been the government agency in charge of funding science, technology and innovation (STI) activities and projects, and also the formulation and implementation of science, technology and innovation policies. It also functions as the secretariat of the National System of Science and Technology (SNCyT by its acronym in Spanish).

In 1991, when the Colombian SNCyT was created by law, the institutional set-up followed Sábato's Triangle model. The composition of the decision-making bodies included representatives of the three sectors: government, the academic-research community, and the productive sector. The triangle model was proposed by two Argentines back in 1968, and has been cited by many academics and practitioners. However, no other country in Latin America has explicitly applied the model in the organization of the governance system of STI. The tripartite representation is not novel in itself, and in many countries STI agencies use government-industry-academia compositions. There are several particularities in the case of Colombia. Firstly, in every instance or decision-taking body there is tripartite participation; secondly, those bodies are neither formal organizations, nor temporary committees, but something in between: formal networks, whose members are appointed for two years, with the possibility of a two year extension.

The organizational arrangement of the Colombian SNCyT makes it different from other countries. My hypothesis is that the strength of the system derives from the application of Sábato's Triangle, despite Colombia having a small research community, few innovators, and a small and unstable public budget for STI. This situation may be somewhat contradictory, but that is exactly

the main objective of the thesis: to analyze the impact of Sábato's Triangle model on the development of the Colombian SNCyT, its cohesion and the recognition granted by the various actors, given these circumstances.

The focus of this thesis is not the content or the outcomes of science, technology and innovation policies but the institutional framework in which they are negotiated and implemented, which determines their effectiveness. Many factors affect the quality of policies, such as institutions and political practices, as well as history, beliefs, leadership and citizen attitudes, as Stein and colleagues say: "Policies are not adopted in a vacuum" (Stein, Tommasi, Echeberria, Lora, & Payne, 2006). What is the novelty of the research? There are studies showing the successes and failures of national science, technology and innovation (STI) policy in Colombia, but few on the evolution and the interactions that occur in the SNCyT. Therefore, the heart of the research will be the SNCyT and its decision-making bodies, and Colciencias as the head of the system. The main objective of this project is to analyze the impact of Sábato's Triangle model on the development of the Colombian SNCyT, looking particularly at the recognition granted by the various actors, and its cohesion.

The focal point will be the Councils of National Programmes of Science and Technology (CPNCyT by its acronym in Spanish), as the principal bodies where the management of scientific and technological activities take place, through the processes of evaluation, selection and approval of projects. The programmes are the axis of the whole SNCyT, and Colciencias' organizational set-up follows the S&T programme dimension. Therefore, the management of STI activities in Colombia is framed by these programmes. In the preliminary research done for the dissertation, I found that the programmatic councils as such have not been analyzed from a governance perspective, and that analysts and practitioners do not agree on the performance and convenience of the councils. One of the specific objectives of this research is to elucidate the role that these programmatic councils (a kind of research council) have played in governing STI and creating linking mechanisms between the research

communities and the government through the dissemination of policies. Other specific objectives are:

- To study the perceptions of the councillors about their role in the SNCyT.
- To characterize the intra and inter relationships between the three groups of actors of the Colombian SNCyT (i.e. government, academia, productive sector).
- To explain the governance of the SNCyT.
- To characterize the underlying communication processes occurring in the interactions of the actors.

This dissertation is organized as follows. Chapter one presents the Latin American school of thought on science, technology and development, with special emphasis on the sixties, when Sábato proposed his model. This chapter will provide the context of the thesis. The second chapter, presents the theoretical framework, aimed mainly at comparing models for representing tripartite relations (i.e. Triple Helix, Sábato's Triangle, National Systems of Innovation –NSI) and understanding how these relations are built and organized. In order to understand research and innovation systems as systems of communication one needs to focus on the interactions between the actors and the networks that are built, rather than on the actors themselves. This entails exploring existing literature on social networks and social capital, and principal-agent theory. In chapter three, I briefly describe the evolution of STI institutions and policies in Colombia, starting when Colciencias was created in 1968, and making emphasis in the era of existence of the SNCyT 1989-2008¹. This chapter includes a section with hard data on the Colombian SNCyT covering the 2000-2008 period. The fourth section deals with methodology. Results are presented in chapter five. And lastly, conclusions and policy recommendations are drawn, and a research agenda proposed.

¹ Since 2006 the SNCyT was informally renamed as National Systems of Science, Technology and innovation (SNCTI by its Spanish acronym). I will use the latter acronym when making reference to the current system and situation, and the original acronym (SNCyT) when making historical references to the original system.

1 THE LATIN AMERICAN SCHOOL OF THOUGHT ON SCIENCE, TECHNOLOGY AND DEVELOPMENT

The way practitioners and academics deal with Science, Technology and Innovation Policies (STIP) has evolved over the past 60 years. Science policy in the Western world was established in the immediate aftermath of World War II, when people recognized the complex, problematic, and sometimes undesirable relationships between power and science². Initially, the main area of intervention and action was limited to science. Since then, government agencies have been created to promote and, especially, to fund science, as well as to establish mechanisms for its governance. In the late 1960s, technology emerged more clearly as an area of concern. Due to budgetary constraints, there was a need for more efficient allocation of resources and amelioration of the impact of science and technology (S&T) on the overall economy and society. It was not until the early 80s that there was a shift towards innovation, gaining a broader understanding of innovation processes that went beyond scientific research and technological development, and focusing on the systemic and interactive nature of these processes. To acknowledge the main focus of the S&T policies does not pretend to argue, for instance, that innovation emerged in the 1980s; it is basically that at that moment governments started to pay more attention to it.

The evolution of STIP can be explained primarily by political and economic factors, closely related to changes in the world economy, the variable nature of the state, environmental concerns and social movements, and the increasing pace of innovation (Biegelbauer & Borrás, 2003; Elzinga & Jamison, 1995). Several authors have established different periods of S&T policy (Elzinga &

² As Salomon states: "The age of institutionalized science policy only really started when scientific activities began to have a direct effect on the course of world affairs, thereby causing the state to become more aware of the field of responsibility which it now could not evade"(Salomon, 1977, p 47).

Jamison, 1995; Gibbons, 2001; Jamison, 1989; Salomon, 1977) although there are similarities between them, as we can see in the table below that presents the various phases and a summary of the principal characteristics of each one.

Most of the empirical and theoretical literature produced in respect of S&T policy reflects the history of OECD (Organization for Economic Co-operation and Development) countries, therefore the examination of the Colombian case will be done having this region as a reference; exception of the Latin American school of thought, movement that gave light to Sábato's Triangle.

Similar phases can be observed in the developing world, especially in Latin American countries, although lagging behind a decade or so. The starting point of public research policy is the 1950s and 60s, when most of the national organizations in charge of S&T policy and funding were created, promoted by international agencies such as the OAS and UNESCO. However, in the first half of the 20th century several important (public) research centers had already been created, focused mainly on scientific investigation³. In the late seventies and throughout the eighties, the focus was on technology management, in particular technology transfer agreements (e.g. terms of trade). During this phase, UNCTAD (United Nations Conference on Trade and Development) and ECLAC (United Nations Economic Commission for Latin American and the Caribbean) played a major role in defining policy issues and helping developing countries to regulate these agreements. In the 1990s, innovation policy clearly emerged in these economies, and many of these countries embraced the systems of innovation approach, which was developed on the basis of the experience of OECD countries.

³ A few examples in Colombia are Cenicafe (National Coffee Research Center), created in 1939, and the ICA (Colombian Agriculture Institute), created in 1962; and in Argentina the CNEA (National Atomic Energy Commission), created in 1950, and the INTA (National Institute of Agricultural Technology), in 1956.

Table 1: Periods of science, technology and innovation policies 1940 until present

Period	Harvey Brooks	Christopher Freeman	Jean Jacques Salomon	Elzinga & Jamison	Andrew Jamison	Michael Gibbons	Summary
1940s - 1950s	Cold war (1945-1965)	Supply-side policies: investment in basic research and education	Infancy (1945-1957)	From Pearl Harbour to Sputnik: military research, large –scale, multidisciplinary and planned project	Science-push: strategic/military research	Policy for Science: the main issue was the growth of scientific enterprise <i>per se</i>	Institutionalization of science policy; scientific hegemony; large-scale science; en-block funding
1950s-1960s							
1960s - 1970s	Dominion of social priorities (1965-1978)	Demand side policies: market concerns, cost-consciousness and effectiveness	Pragmatism (1957-1967)	From Sputnik to Vietnam: university science, peer review processes	Economic phase: concern with tech development, market-pull, international coordination of STIP	Science in policy: science was perceived to support the objectives of other policies	Social accountability: social upheaval; budgetary constraints; project funded orientation; technological development
1970s - 1980s			Questioning	Social relevance: social movements, politics back into discussions of STIP	A new social focus: sociological study of STI		
1980s - 1990s	Innovation policy	Combination of supply and demand policies		Orchestration: commercial orientation, emphasis on industrial innovation and technological forecasting	Polarization	Policy for technological innovation	Innovation; commercial orientation; entrepreneurs; innovative regions and clusters
1990s - until present				Globalization and indigenization			

Source: Prepared by the author based on Elzinga & Jamison (1995), Gibbons (2001), Jamison (1989), Salomon (1977).

This characterization may be overly simplified, and it may overlook some issues regarding S&T thinking and development in certain Latin American countries, especially the largest and more developed, such as Brazil, Argentina and Mexico⁴. However, it reflects the evolution of most of the region, despite the more advanced thinking and discourse of regional experts, as I will present later on. Two periods of studies and thinking on science and technology can be identified in Latin America. The first one covers the 1960s and 1970s, and the second one began in the 1980s. The first period was guided primarily by the experience and ideas of researchers and policy practitioners; the most recent epoch, although the community of exponents is less integrated⁵, encompasses a group of people with postgraduate education in policy, management, or social studies in science, technology and innovation. In the first section of this chapter I will concentrate on the first period, taking into account that the object of study, Sábato's Triangle model, was developed during that time, although the main period of analysis of the Colombian STI agency, Colciencias, is 1989-2008.

In Latin America, a school of thought on science, technology and development emerged in the 1950s, which was based on practice rather than theory. The school was not based on a particular discipline, theory or methodology, nor was it a formal body of scholars or associated academics; therefore, it cannot be considered a conventional school of thought (Martínez-Vidal & Marí, 2002). Despite the above, the school was very influential because of the political positions and discourse of its promoters (Dagnino, Thomas, & Davyt, 1996)⁶. Máximo Halty, Jorge Sábato, Marcelo Alonso, Amílcar Herrera,

⁴ The national S&T agencies in these countries were created in the fifties: in Brazil the CNPq in 1951, the CONICET in Argentina in 1958, and in Mexico the precursor of the CONACYT, the INIC, in 1950.

⁵ Less integrated in the sense that they possibly do not recognize themselves as an academic school; however, they interact in various international and regional conferences, (e.g. Esocite, Altec, etc.), they produce regional academic journals (e.g. *Revista REDES*, *Revista Iberoamericana de Ciencia Tecnología y Sociedad*), and there are regional postgraduate programmes on the topic (e.g. in the universities of Campinas in Brazil, and Quilmes in Argentina.)

⁶ Dagnino and colleagues affirm that the main interest of this group was not S&T activities as such; S&T as an area of concern was instrumental to their socio-political interests. Because they came from different backgrounds and political parties, these authors questioned the idea that the

Francisco Sagasti, Miguel Wionczek, and Carlos Martínez-Vidal⁷ are emblematic of this school (Casas, 2004; Jaramillo, Botiva, & Zambrano, 2004; Martínez-Vidal & Marí, 2002). The closeness of these thinkers to international agencies was clear; for instance, Halty and Alonso were the directors of a regional OAS S&T programme, and Sagasti was the coordinator of a programme known as “Science and Technology Policy Instruments” (STPI)⁸ funded by IDRC (International Development Research Center of Canada) and the OAS.

This Latin American school of thought formulated a research and innovation policy which was advanced for its time, because it went beyond the traditional supply and demand perspective and was critical of the linear model (Casas, 2004). The main proposals were that autonomous technological development was possible, and that it was crucial for endogenous and integral development, incorporating social concerns and looking at the relations between S&T and society. In this sense, there are clear connections between the formulations of this school and “dependency theory” developed by ECLAC. It is also remarkable that in those early writings innovation, and not just scientific research, was clearly stated in the discourse. However, technological development and innovation were timidly addressed by national policies and few industries were involved in those activities (Dagnino, et al., 1996; Katz, 1984, 1987). It is important to mention that, from an economic development perspective, the 1930-1980 period is known in Latin America as “industrialization via import substitution”, which is characterized by high protectionism of national industries, foreign investment (start up of transnational companies), and not much interest in the development of endogenous scientific and technological capabilities; modernization was obtained through the import of foreign technologies (Dagnino, et al., 1996, p. 18; Fajnzylber, 1990; Katz, 1984; Salazar, 1994).

school could be considered a community of science, technology and society studies (Dagnino, et al., 1996).

⁷ Their country of origin is varied: Argentina, Peru, Brazil, Uruguay, and Mexico.

⁸ This programme has highly influential because it provided an interesting benchmarking and learning platform for the developing world. Countries from very different regions were involved, such as Colombia, Macedonia, Korea and India.

Martínez-Vidal and Marí say that the school had difficulty promoting its points of view because “explicit” policy-making was dominated by scientists and “implicit” policy-making by orthodox economists⁹ (Martínez-Vidal & Marí, 2002, p. 12). The incoherence between the objectives of the explicit and the implicit S&T policies is evident because of the predominance of economic and industrial policies (Dagnino, et al., 1996, p. 22; Salazar, 1994). Martínez-Vidal and Marí also say that the impact of the school should be evaluated on the basis of its achievements rather than its writings, because it was based on practice and not on theory. Even if dependency theory is associated with the S&T for development school, one cannot say that the latter is a theory. While it has certainly coined several concepts, such as explicit/implicit policies, and tripartite relationships (i.e. Sabato’s Triangle model), which can be used as analytical categories, it does not allow in-depth analyses. Oteiza confirmed that this advanced conception of S&T policy was not adopted into real policies and did not affect the power elites. He argues that this was due to a cultural problem in two dimensions: S&T and general culture, and S&T and power elites. The first has to do with S&T not being fully appropriated by Latin American societies and seen primarily as exogenous elements. The second refers to the marginalization of research communities from power circles, situation that did not contribute to understanding the importance of scientific and technological development by our elites (Oteiza, 1997).

The creation of science councils in Latin America¹⁰ was strongly influenced by this movement and received support from international agencies, in particular UNESCO and the OAS. However, the recommendations varied depending on the multilateral agency. UNESCO was mainly oriented towards

⁹ Amílcar Herrera introduced in the region the concepts of explicit and implicit policies. Explicit policies were science and technology policies as such, and implicit policies were other policies that had an effect on scientific and technological development, such as industrial or trade policy (Herrera, 1995, original 1971).

¹⁰ Even if there are many differences between Latin American countries, either in size or degree of development, many participated in the meetings organized to discuss the movement’s proposals, and similarities can be found in the councils created, as well as differences. Some were mainly oriented towards funding R&D, others included research activities as such in their functions, and others were advisory councils.

supply policies and the support of scientific infrastructure, and the OAS was highly supportive of the Latin American school of thought. In the end, however, a hybrid model prevailed, supporting both technological development and scientific research (Martínez-Vidal & Marí, 2002, p. 8). In this sense, institutional arrangements, such as the national organizations for the development of science and technology (ONCyT for its acronym in Spanish), created during the sixties, can be considered the main result of the school.

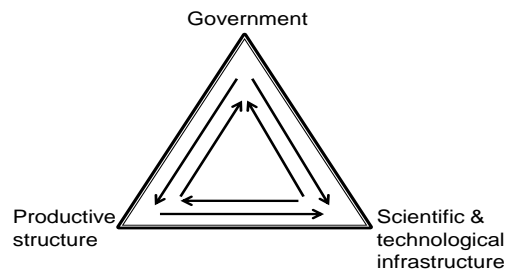
1.1 Sábato's Triangle model

The S&T School for development was mainly directed towards S&T policy rather than S&T institutional arrangements; however, most of the national S&T agencies in Latin American countries were created between the fifties and the seventies, under the influence of this school and multilateral agencies. This school had clear ideas about research and innovation strategies, and the diverse groups of actors that should come together to make them happen. This is where Sábato's Triangle comes into play. It offers a simple but clear figure to depict the three elements or groups of actors that have historically been fundamental in the development of science and technology: government, the productive structure, and the scientific and technological infrastructure, as they have been called by Sábato and Botana¹¹. The vertices are characterized from a functional perspective and not by their legal nature (e.g. a public firm is part of the productive structure, not the government). Subsequently, many authors proposed more sophisticated diagrams¹².

¹¹ Jorge A. Sábato (1924-1983) was an Argentinean physicist and technologist. He joined the CNEA (National Commission of Atomic Energy) in 1955 and created the metallurgy department. For many years he was interested in the relationships between science, technology and development. Natalio R. Botana (1937) is a political scientist, also born in Argentina. He wrote this paper with Sábato in 1968, but science and technology did not remain his area of interest. Today he writes a column in the Argentinean newspaper *La Nación*.

¹² For instance Sagasti based on Sábato's triangle, introduced a fourth vertex representing the financial system (Sagasti, 1983). One can argue that the Triple Helix of innovation model is a more sophisticated form of depicting the tripartite relationships, compared to a simple 'static' triangle; however there is no clear evidence that Etzkowitz and Leydesdorff, the originators of the

Figure 1: Sábato's Triangle



Source: Sábato & Botana, 1968.

Martínez-Vidal and Marí (2002) agree that the culminating moment of the Latin American school of thought was the (now) famous 1968 article by Sábato and Botana¹³, in which they propose the triangle of scientific and technological tripartite relations. Each vertex also constitutes a convergence point of multiple institutions, decision agents, production units, etc. Below is my translation of the original definitions provided by Sábato and Botana:

- Government is understood as a set of institutional roles which have the objectives of policy formulation and resource mobilization from and to the vertices “productive structure” and “scientific and technological infrastructure” through legislative and administrative processes.
- The productive structure is defined as the set of productive sectors that provide the goods and services which a specific society demands.
- Scientific and technological infrastructure “is composed of a group of articulated and interrelated elements:

Triple Helix model, knew of Sábato's model before they proposed theirs in 1996. The first time they make a proper reference to Sábato's Triangle is in their 2000 article (Etzkowitz & Leydesdorff, 2000, p. 109). However, in an earlier article Etzkowitz, Mello and Terra make a brief mention of Sábato's Triangle, presenting the evolution of innovation policy in the State of Rio de Janeiro, Brazil, and the leading role that the government had in developing the industrial and research spheres (Etzkowitz, Mello, & Terra, 1998, p. 366).

¹³ The article was the result of an assignment made by the director of the Latin American Institute for Integration, to be presented at “The World Order Models Conference”, held in Italy in September 1968, and then published in the journal of that institute. A slight variation of that article is found in the 1975 book edited by Sábato.

- The education system, which provides the quantity and quality of ‘men’¹⁴ who conduct research: scientists, technicians, assistants, operators and administrators.
- Research institutes, lab centers, and pilot plants (formed by ‘men’, equipment, and buildings where research is done).
- Research planning, coordination and support (granting) organizations (e.g. research councils, science academies, etc.).
- The administrative and legal mechanisms that regulate the functioning of the above elements and activities.
- The economic and financial resources applied to its functioning (Sábato & Botana, 1968, pp. 3-5).

It is interesting to note that Sábato and Botana included S&T policy-making and granting agencies as part of the scientific and technological infrastructure and not of the governmental sector. Félix Moreno, one of the Colombian exponents of the Latin American school of thought, said back in 1975:

S&T agencies have only recently been created in Latin America, but their importance is rapidly being recognized both by government agencies and research centers. Unfortunately in some countries they have been created with an academic bias, very focused on scientific supply, and in many cases depend on the Ministry of Education, which prevents them from having an influence on the productive sector or on economic and social policy” (Moreno, 1975, p. 273).

Moreno’s comment should certainly not surprise us, since the model proposed by Sábato and Botana, and followed by Latin American governments to a greater or lesser extent, gave the idea that S&T policy-making institutions should be closer to the academic and research communities than to the government, despite the policy recommendations which gave an important role to technological development and innovation activities.

What does the triangle try to show us? How can we use it? In an attempt to answer these questions, Sábato and Botana argue that “the model does not only aim to be an analytical instrument that represents reality, but also

¹⁴ As in the original.

demonstrates that the mere existence of the triangle ensures the rational capacity of a society to know where and how to innovate” (Sábato & Botana, 1968, p. 5). In this sense, the model is normative, as it presents how things should be, as the three sectors should come together to define a national STI strategy, the capabilities that each vertex should have to do what they have to do, and through the resulting relations between them, they implement the strategy. Oteiza partially reinterprets Sábato and Botana’s approach. He talks about an open or closed triangle, explaining that when the triangle closes the ties between the three vertices are created, dynamic knowledge is generated, and transfer to society is achieved (Oteiza, 1997, p. 127).

Sábato and Botana propose that the government vertex requires the capacity to take deliberate action in policy formulation and implementation; the scientific and technological infrastructure vertex must have creative capability; and the productive structure vertex requires the entrepreneurial capability necessary to ensure the fulfillment of its task of producing goods and services. In 1968, they said that Latin American governments did not have the capacity to formulate and execute S&T policies; this may explain why they did not consider S&T planning agencies as part of the government sector. This statement also reinforces the idea that Sábato’s Triangle model is normative; it was not based on what they were actually observing in Latin American countries, but rather on how they wanted national STI policy to be. It was an ideal model that was non-existent in the region.

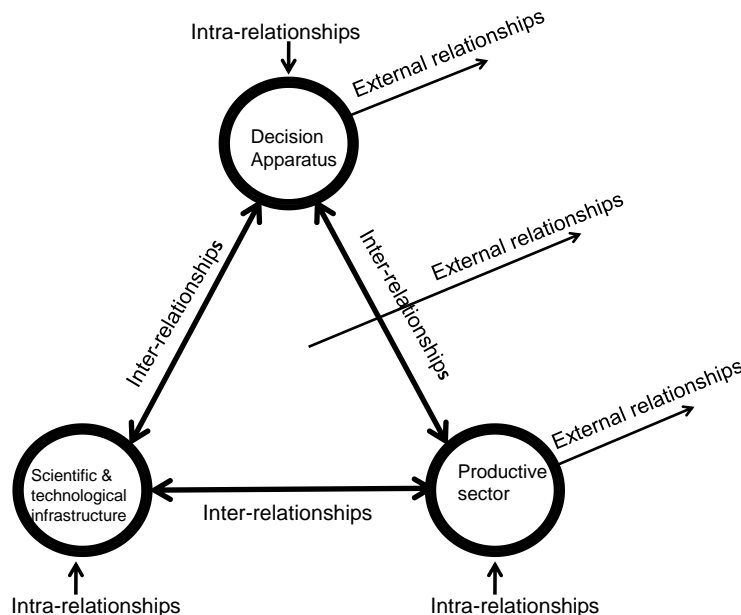
Amaya and Alvarado¹⁵ re-interpret the names of Sábato and Botana’s vertices, especially government, which they define as the “decision apparatus”, which involves all entities, public or private, that participate in policy formulation. They also explained the productive structure in more detail, “which includes both national and foreign entities residing in the country where the sale of goods and services occurs, regardless of their economic activity (e.g. agriculture,

¹⁵ Mr. Alvarado was then head of the statistical unit of Colciencias; and Mr. Amaya was then deputy director of national budgeting of the Ministry of Finance, and later general director of Colciencias (1986-1990).

manufacturing, construction, transport, communications, finance, healthcare or real estate). It also covers government-owned production companies and nationalized industries which have the functions of a production company, not with regard to the legal form that regulates it, but to the purpose of the activity. It includes all the entities engaged in the extraction, exploitation, and production of goods and those that provide, supply and sell services” (Salomon, 1977b, p. 157).

As mentioned above, it can clearly be inferred that a series of relations between the triangle components exist, and that the actual existence or lack of these relationships as well as their fluidity and intensity is what characterizes the triangle (Salomon, 1977a, p. 159). The model distinguishes three levels of relations: i) the ones established within each vertex (intra-relations); ii) the ones between the three vertices of the triangle (interrelations); and iii) those that are established between the triangle (or between each one of the components) and the external environment (external relations).

Figure 2: Scientific and technological triangle



Source: Amaya & Alvarado, 1977

Sábato and Botana explain the objective and principal ties established or desired between the vertices. Starting with the first level, they say: “The

relationships established within each vertex (intra-relations) have the objective of transforming these convergence centers into centers capable of generating, incorporating and transforming demands into a final product, which is scientific and technological innovation. In this sense, the different relationships that constitute each vertex must structure themselves in order to guarantee a specific capability” (see figure above) (Sábato & Botana, 1968, p. 6).

The interrelations between the three groups of actors are the most important for explaining and evaluating the performance of an S&T system, an integrating the triangle. It is at this level where, according to Sábato and Botana, the generation of self-decision capability in the field of science and technology is placed and observed. They say that the interrelation between the government and scientific and technological infrastructure takes place through two flows: resource allocation by the government to the vertex of S&T infrastructure, as the former virtually depends on the deliberate action of the government, and the demand for knowledge and technology generated by the government. The government - productive structure interrelationship depends fundamentally on the capacity of both vertices to make use of existing knowledge and incorporate it into productive systems. The authors say that the government is related to the productive structure through the action taken on scientific and technological infrastructure, implying no direct government intervention or funding of the productive sector. Finally, they say that the relations between the productive structure and the scientific and technological infrastructure are the most difficult to establish and identify. The authors mention that through the interchange of personnel (occupational mobility) the two vertices can share ideas and potential mutual demands (Sábato & Botana, 1968, pp. 7-8). In a later article, Sábato says that to be able to formulate specific S&T strategies, it will be needed to characterize triangles for every sector (Sábato, 1973).

Regarding external relationships, Sabato & Botana state that these are from the vertices towards the exterior, rather than thinking of possible intervention or inputs from external or international actors to the triangle.

Alongside this, they argue that part of a good working triangle has the ability to export and import S&T.

Amaya and Alvarado further develop some hypothetical relations and key relationships between components:

- The decision sector and the productive sector present specific demands (in terms of problems to solve) to the scientific and technological system and provide resources for their activities.
- The decision sector has the capacity to promote and guide the activities of the scientific and technological system through explicit or implicit policies in this field, or through specific sector policies.
- The scientific and technological system, through the application of knowledge, looks for solutions to the problems of the other two sectors (Amaya & Alvarado, 1977, p. 159).

As simple as Sábato's proposal was, it is a useful and powerful tool for policy practitioners, and "new" explanations of the triangle have been developed, as follows:

- According to Oteiza the model postulates: in order to produce a sustained flow of knowledge and transfer its results to society, S&T investigation needs to relate what has been 'divorced' in our region (the vertices of the triangle: government and State, R&D activities, and production units) (Oteiza, 1997, p. 127).
- Jaramillo and colleagues state: "The Triangle of Sábato is an analytical model that explains the complex relationships that occur between science and its applications, between supply and demand of knowledge, and between the roles played by diverse actors (academia, firms and government)" (Jaramillo, et al., 2004).

The focal point of the thesis is to study Sábato's Triangle and the impact it has had in the development of the Colombian S&T system. Nonetheless, this model does not provide enough keys to have a deep and broad comprehension

of the SNCyT. Therefore in the next chapter other theories and approaches will be introduced in order to inform governance and networking aspects of research and innovation systems, especially looking at ways to operationalize interactions and communication channels between actors.

2 THEORETICAL FRAMEWORK

For the purposes of this thesis, I reviewed literature related to studies on Science and Technology, either from a policy and economic perspective or social perspective. These bodies of literature highlight the major issues at stake: systems of governance and policy-making of S&T, and the underlying communication processes. With respect to Social Studies of Science and Technology (SSS&T), especially the sociology of S&T, did not contribute much to the subject, with the exception of the Actor Network Theory, which will be referred to in section 2.2. With regard to Science and Technology Policy studies (STP), the literature provided input for understanding communication channels, interactions, and linkages among the main actors in an STI system. In this sense, different STP approaches were reviewed, such as systems of innovation, Triple Helix model, and principal-agent theory. I use the word “approaches”, rather than theories, because this field of studies is “heavily under-theorised”, despite having a long tradition, as stated by Braun and Guston (2003).

SSS&T have been traditionally separated from STP studies. There are several explanations for this division: their disciplinary origin, their major sources of research questions, the consequent emphasis on cognitive or operational problems, and their focus on science or technology (Spiegel-Rosing, 1977, p. 17). SSS&T, with strong roots in its mother disciplines - primarily sociology, history and philosophy - imply that they have different intellectual traditions. STP studies, on the other hand, evolving mainly from economics and, more recently, management, are therefore less fragmented.

SSS&T focuses mainly on knowledge creation, how science functions, and somewhat neglecting policy and control issues. Nevertheless, SSS&T raise ethical, political and gender-related issues regarding S&T development, which should be important inputs for policy making but are not always considered. While STP studies has been more concerned about proposing how S&T can be promoted, governed and directed; its problems are generated in the world of S&T

management and practice. At present, science policy studies have been subsumed by the systems of innovation approach (Guston, 1996).

Attempting to understand science and innovation systems as systems of communication from a sociological rather than economic perspective, one needs to focus on networks and the interactions between actors, rather than on the actors themselves¹⁶. This entails exploring existing literature on social networks, social capital and actor network theory. Wellman and Berkowitz say “social structures can be represented as *networks* – as sets of *nodes* (or social system members) and sets of *ties* depicting their interconnection (Wellman & Berkowitz, 1988, p. 4)¹⁷. In this sense Sanz-Menéndez notes that this conceptualization entails moving from a metaphor to an analytical tool that uses the mathematical language of the graph theory, matrixes, and relational algebra (Sanz-Menéndez, 2003, p. 25). Wellman and Berkowitz further explain that nodes, generally associated with individual persons, can also represent groups, organizations, advisory councils, regions, nation-states, or other communities. Finally, ties can represent flows of resources, friendships, or transfers (of goods, services, information). However, it is important to emphasize that a network is much more than the sum of its ties. According to these authors, when doing network analysis we identify not only the nodes and the ties that relate these nodes, but also the patterns of these relationships.

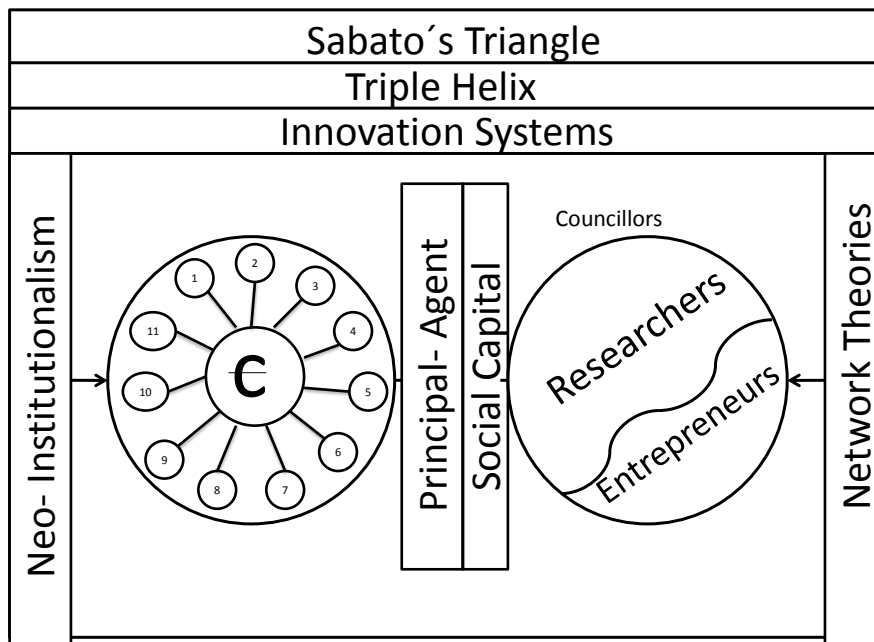
The system of innovation, the Triple Helix, and the Triangle of Sabato models will provide me with the analytical and normative frameworks to explain the organization and representation of the Colombian SNCyT. Then neo-institutionalism and network theories, more specifically principal-agent theory and social capital, respectively, will provide the basis for understanding the relations between institutions and individuals, institutions being Colciencias and the Councils of National Programmes of Science and Technology (CPNCyT), and individuals being the councillors, either researchers or entrepreneurs, who have

¹⁶ The description of actors is the usual analysis done from the “system of innovation” perspective.

¹⁷ Emphasis added.

a central role in the SNCyT. Even if these theories were not originally developed in the STP field, they have been used in several studies, especially the principal-agent theory, which has been used to explain the power relationships between the state, the research councils, and the scientists, as will be presented in sections 2.3.

Figure 3: Theoretical framework



Note: C: Colciencias; 1-11 CPNCyT

Source: Prepared by the author.

2.1 Models for representing university-industry-government relations in respect of STI development

Different models have been proposed to study science, technology and innovation systems or knowledge-based systems, and the relations between the main actors - government, industry and academia - such as:

- National Systems of Innovation –NSI (Edquist, 2005, 1997b; Edquist & Hommen, 1999; Lundvall, 1992; Lundvall, Johnson, Anderson, & Dalum, 2002; Nelson, 1993).

- Triple Helix model of university-industry-government relations (see Etzkowitz & Leydesdorff, 2000; Leydesdorff, 1998; Leydesdorff, 2000; Leydesdorff & Meyer, 2003).
- Triangle of Sabato (see Sabato, 1975; Sabato & Botana, 1968)¹⁸.
- 'Mode 2' type of knowledge production (see Gibbons, et al., 1994; Nowotny, Scott, & Gibbons, 2001).

These models are mainly used to explain processes related to: i) the generation and diffusion of knowledge, and, ii) the formulation and implementation of policies. In general, they can also describe how crucial information is disseminated within the systems. All attempt to understand the relationships between three types of actors: industry, academia and government; although none of the models take into account society in general. Generally speaking, the approaches emphasize several aspects: flux of information, institutional arrangements, and relationships, pointing to an enhanced role of knowledge in the economy and society (Etzkowitz & Leydesdorff, 2000). The main difference between the models is who plays the primary role; in the words of Etzkowitz and Leydesdorff: "The Triple Helix thesis states that the university can play an enhanced role in innovation in increasingly knowledge-based societies. The NSI approach considers the firm as having the leading role in innovation and, in the Triangle model of Sabato, the state is privileged" (Etzkowitz & Leydesdorff, 2000, p. 109).

For the purposes of the thesis, the first three models are essential because they all focus on tripartite relations. In Colombia, Sabato's Triangle model and the National Innovation System approach were adopted for the organization of the National System of Science, Technology and Innovation (SNCTI), as it is known today the SNCyT. Sabato's Triangle model was explained in chapter 1, so I will not describe it again. There is no definitive evidence as to whether Etzkowitz and Leydesdorff knew of Sabato's Triangle before they proposed their Triple Helix model in 1996 (see footnote 10). The

¹⁸ In the 1975 book Sabato compiled many of the contributions to the Latin American School of Thought, included a revision of his article with Botana.

similarities between both frameworks are evident, but the uses and advances of each one are quite different; there is much more literature (empirical and theoretical) on the Triple Helix model, which provides deeper and better insight into those tripartite relationships. To my knowledge, Sabato's ideas were not further developed, even if the article is cited by many academics¹⁹. In this sense, this thesis is innovative because it will test this model, which has been purposely applied in Colombia²⁰. Meanwhile, the Triple Helix approach is very well institutionalized (international conferences) and many studies have been done applying the model (see books published²¹ and special editions of the journals *Science and Public Policy* and *Research Policy*). I will start by explaining the systems of innovation approach, since it emerged a bit earlier than the Triple Helix.

2.1.1 Innovation systems

In the late 1980s a new current emerged within science and technology policy and innovation studies: the systems of innovation approach, whose precursors were Christopher Freeman, Bengt-Åke Lundvall, and Richard Nelson. The approach was developed from historical-empirical analyses and is based on evolutionary theories of technical change, institutional economics, and the chain-link or interactive model of innovation. It originated from findings in different research areas. The scholar who introduced²² the concept of 'National Systems of Innovation' (NSI) was Freeman, in a case study of Japan in 1987²³. Lundvall further developed the theoretical and conceptual foundations of NSI, using

¹⁹ In Google Scholar, Sabato & Botana original article appears to be cited 145 times.

²⁰ Even if Sabato's Triangle is frequently mentioned by Latin American S&T practitioners and scholars, the model has not been formally applied by another country different from Colombia.

²¹ For instance: Etzkowitz, H. (2008). *Triple Helix Innovation: Industry, University and Government in Action*. London and New York: Routledge.

²² Freeman affirms that Lundvall was the first to use the term, but in written form it first appeared in Freeman's book. The idea of national systems of innovation was already apparent in the work of the IKE-group in Aalborg in the first half of the 80s, but they spoke mainly about national systems of production.

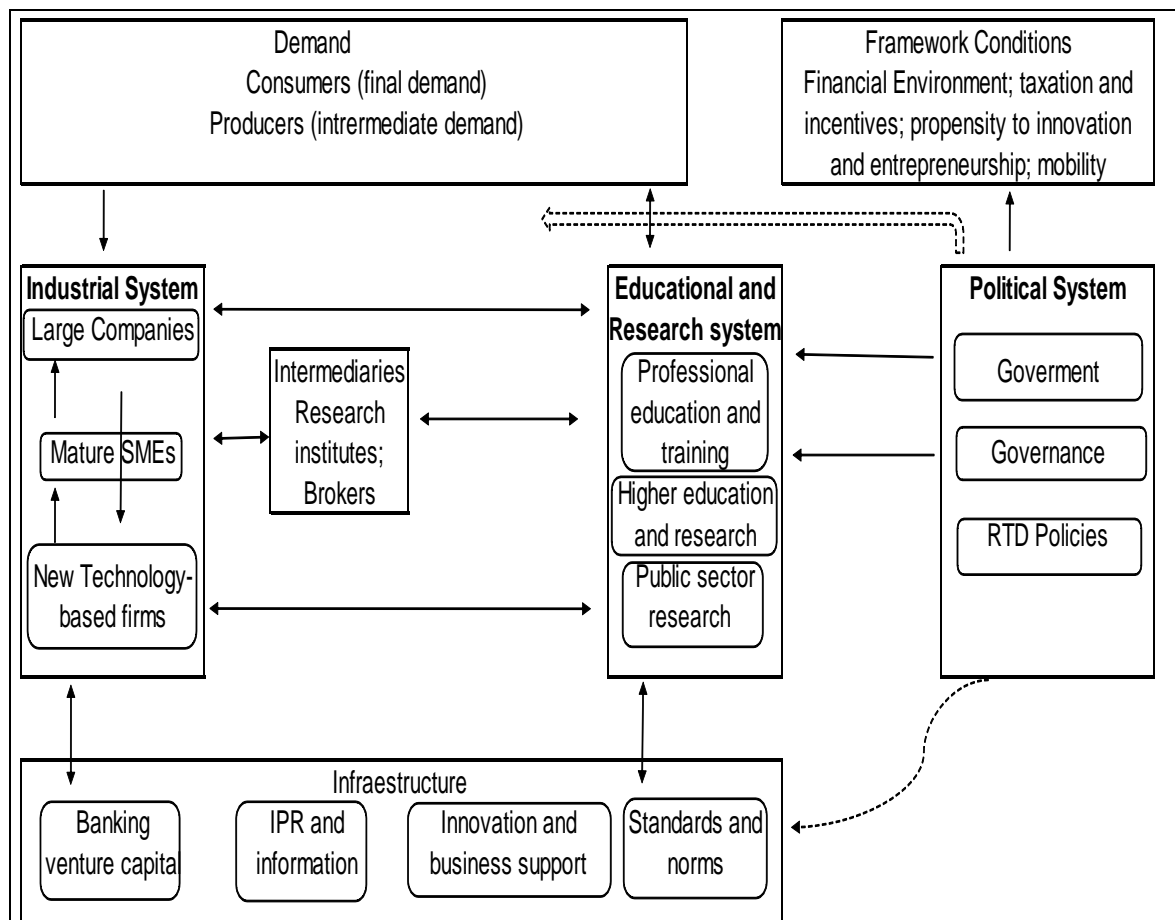
²³ See Freeman, C. (1987). *Technology policy and economic performance: lessons from Japan*. London; New York: Pinter Publishers.

Denmark as an example²⁴. Nelson edited a book in 1993 with fifteen case studies of NSI (Nelson, 1993). Since then, many books and articles have been written based on the concept; but, as many researchers have pointed out (see Edquist, 1997a; Holbrook & Wolfe, 2000; Nelson & Rosenberg, 1993), there is still no 'formal' NSI theory. Nevertheless, theories of interactive learning together with evolutionary theories of technical change are considered to be the theoretical foundations of the systems of innovation approach (Edquist, 1997a).

Castellacci and colleagues assert that there are two traditions within innovation systems: a historical-empirical approach (NSI approach, e.g. Nelson's book) and an interactive learning-based approach (the Aalborg school) (Castellacci, Grodal, Mendonca, & Wibe, 2004). The former is the more established and developed of the two. The historical-empirical branch emerged when researchers and practitioners observed how firms in different countries performed differently, recognizing, on the one hand, that national capabilities affect the performance and competitiveness of the firms. On the other hand, they also understood that firms do not innovate on their own; they rely on various supporting organizations and institutions. In this sense, innovation systems attempt to understand and "decipher" the environment that surrounds firms. This version of the NSI focuses on the institutional set-up that supports and promotes innovation activities. Below is a graph that shows the principal actors of an NSI, by sector (i.e. political; educational and research; and, industrial), as well as the regulatory and supportive infrastructure. NSI representations, as the one shown, tend to focus on formal organizations and the main functions nor the infrastructure needed to foster innovation, such as venture capital and an adequate intellectual property regime, just to mention a few. It also depicts general economic conditions. From this figure I will highlight the political system, which includes the government, the governance mechanisms and the R&D policies as such, that is the focal point of this research.

²⁴ See Lundvall, B.-A. (Ed.). (1992). *National Innovation Systems: Towards a Theory of Innovation and Interactive Learning*. London: Pinter Publishers.

Figure 4: National Innovation System set up



Source: Arnold & Kuhlman (2001)²⁵, as cited in Arnold, 2004.

In contrast, the Aalborg school started from two basic assumptions: i) knowledge is the most fundamental resource in the modern economy, making learning the most important process; and, ii) learning is interactive. This orientation emphasized the concept of a knowledge-based (or learning) economy (Castellacci, et al., 2004, p. 11). Scholars from Aalborg say that their “version of the NSI concept may be seen as a combination of four elements: the neo-Schumpeterian reinterpretation of national production systems, empirical work based on the home-market theory of international trade, the microeconomic

²⁵ Arnold, E. & Kuhlman, S. (2001), *RCN in the Norwegian Research and Innovation System*, Background Report No 12 in the Evaluation of the Research Council of Norway (Royal Norwegian Ministry for Education, Research and Church Affairs: Oslo). Also available at www.technopolis-group.com

approach to innovation as an interactive process inspired by research at SPRU²⁶, and, finally, insights in the role of institutions in shaping innovative activities” (Lundvall, et al., 2002, pp. 216-217). Castellacci and colleagues argue that the regional approach resembles the Aalborg school and not the historical-empirical version, because more emphasis is placed on the social aspects of innovation²⁷.

The approach to innovation systems is not understood as a theory in itself, but as a conceptual and analytical framework to understand the complexities of the innovation processes and the institutional arrangements that affect it. This empirical and conceptual literature uses a broad concept of system²⁸, considering first that these systems are not created on purpose, that they do not always work in a consistent and coherent manner, and that not all links between components exist at a given moment in time, so they must be constructed or facilitated (Edquist, 1997a; Nelson & Rosenberg, 1993). Earlier studies on innovation systems were highly descriptive, enumerating the agencies, their functions, and the relationships between them, similar to a checklist, as Rip and van der Meulen stated (1996). More recent studies attempt to identify gaps, breaches and bottlenecks in respect of organizations and the relationships between them.

Two features of NSI are worth emphasizing: the notion of optimality, and the debate about “creationism” or “spontaneous evolution”. As Edquist notes, there are “some elements of the systems of innovation consciously designed by actors, sometimes government policy-makers, but others seem to evolve spontaneously over extended time periods” (Edquist, 1997a, p. 13). Surely, a

²⁶ SPRU is the Science Policy Research Unit at the University of Sussex in England.

²⁷ The literature on regional innovation systems recognizes that innovation is: i) a *social process* and is shaped by persons and institutions that share a common language, rules, norms and culture (i.e. common modes of communication); and, ii) a *geographic process*, taking into account that technological capabilities are grounded in regional communities that share a common knowledge base (Holbrook & Salazar, 2004).

²⁸ According to the Webster dictionary, a system is a complex unity formed of many often diverse parts subject to a common plan or serving a common purpose; or an aggregation or assemblage of objects joined in regular interaction or interdependence (*Webster's Third New International Dictionary, Unabridged*. Merriam-Webster, 2002. <http://unabridged.merriam-webster.com>. 7 July 2010).

national system could not be designed as a whole; there is not a model defined *a priori*. Moreover, the concept of optimality is absent from the system of innovation approach, since there is not an ideal system against which one can compare. Besides an innovation system is context specific. This is true for both for OECD and Latin American countries. Edquist points out:

We cannot define an optimal system of innovation because evolutionary learning processes are important in such systems and they are subject to continuous change. The system never achieves equilibrium since the evolutionary processes are open ended and path dependent (Edquist, 1997a, p. 20).

In analyzing the origins and development of the concept, Rodrigo Arocena and Judith Sutz, both from Uruguay, found an important distinction between developed and developing countries. NSI is an *ex-post* concept for developed countries, built upon empirical studies which show similar organizational patterns around innovation. The institutions already exist and work together with the firms; there are innovation networks. In this case the NSI approach explains how these networks function. For Latin America, NSI is an *ex-ante* concept, in the sense that governments have created technology related institutions and are trying to build networks to promote innovation at the firm level, on the basis of the NSI model. They add that this is not insignificant, because in Latin America “very few patterns of the socio-economic behaviour regarding innovation can be viewed as working in a system-like manner” (Arocena & Sutz, 1999, p. 5). Following the idea of Arocena and Sutz, one could argue that the NSI concept in developing countries has been used more frequently as a normative framework rather than as an analytical tool. In the case of Colombia, the national government has created organizations oriented to support innovation, such as technological development centres thought as intermediaries between the research system and the industry, technological parks and incubators to house start-ups and spin-offs, and venture capital funds, without a clear demand for those instruments.

When scholars introduced the concept in European countries, where much of the innovation system approach was developed, the NSI were already

established with working organizations and linkages between the different actors. The systems were well defined and developed. In North American countries (USA, Canada and Mexico), even if the agencies have already been working together and interacting with firms, one cannot assume that NSI are well defined because of the large size of these countries (from any dimension: territory, population, or GDP) and their federal system (Salazar & Holbrook, 2007). Perhaps this is why the literature on clusters emerged in the United States. Michael Porter, the forerunner of the cluster approach, tried to explain why some regions within a “competitive country” (i.e. within an NSI) were more competitive than others.

In Latin American countries, including Colombia, the concept has been used to guide the design of policies and instruments; to build and organize the system, in other words, to set up the institutional infrastructure; and, to facilitate the linkages between the different actors. In the Colombian case, for example, the model was applied when the system of innovation was formally launched in 1995 and the supporting institutions were created (normative approach), but few studies use it to explain the performance of the system (see for instance Durán, Ibañez, Salazar, & Vargas, 1998; Salazar, 1998).

Before introducing the different definitions of NSI, it is important to establish how systems of innovations are characterized. Systems comprise ‘components’ and the ‘relations’ among them. The main components are formal organizations and informal institutions²⁹. Relations can be described and measured through information and knowledge circulation as well as financial flows. It should be possible to identify the boundaries of a system, national, regional, local or technological.

²⁹ Some authors make a distinction between institutions and organizations when analyzing innovation systems, defining institutions as a set of common habits, routines, rules or laws that regulate the relations and interactions between individuals and groups; and organizations as formal structures with an explicit purpose and consciously created (Edquist & Johnson, 1997). However, along this document I will use both terms synonymously, unless I make the specific distinction.

Nelson and Rosenberg (1993) define an NSI as the interaction of the innovative capabilities of firms with a set of institutions that determine the firm's capacity to innovate. Holbrook and Wolfe have summarized the key characteristics of an NSI:

- Firms are part of a network of public and private sector institutions whose activities and interactions initiate, import, modify and disseminate new technologies.
- An NSI consists of linkages (both formal and informal) between institutions.
- An NSI includes flows of intellectual resources between institutions.
- Analysis of NSI emphasizes learning as a key economic resource and that geography and location matters (Holbrook & Wolfe, 2000).

The system of innovation approach is clearly central to this dissertation, not only because the object of study is the Colombian Science, Technology and Innovation System (SNCTI), whose orientation was illustrated by this body of literature, but also because, in practice, it is the framework where the various actors operate and through which policies, ideas, people and knowledge circulate.

However, this literature has its limitations for the purposes of the thesis. In the first place: the forms of representation. The NSI literature usually depicts the systems by differentiating among the most important actors and highlighting the central functions needed (see Figure 4 above). Meanwhile, representations of the Colombian SNCTI (see Figure 12 in chapter three), do not display the different participating organizations, but rather the organization of the political system (especially government and governance), following Arnold and Kuhlman's scheme. None of the illustrations are particularly useful for showing the linkages between institutions and individuals, in other words to visualize social networks. Secondly, the NSI focal point is enterprises, and the focus of this thesis is a governmental agency and its relationships with different communities. In third place, studies that deal with national-level innovation systems have not been

able to address essential 'social' issues regarding innovation, such as trust, norms, and culture (i.e. codes of communication), while the regional approach has concentrated on those aspects as well as the territorial dimension (Holbrook & Salazar, 2004; Holbrook, et al., 2004). Furthermore, this framework does not provide clues for social network analysis or explaining how social capital is built.

Rip and van der Meulen criticize the use of the innovation system approach by policy analysts because it is mainly descriptive, enumerating the institutions, the procedures and their performance. As they say: "The concept functions as a checklist. If the items on the checklist are not an interdependent part of a system, it makes no sense to articulate performance measures to the presumed national system of innovation" (Rip & van der Meulen, 1996, p. 344). Smits and Kuhlman provide a good example of a common way of describing the components of an NSI:

- Supply-side: production of knowledge, research system.
- Demand-side: consumers, firms, governmental departments, and other users of knowledge-based products and services.
- Intermediary infrastructure: institutions, mechanisms and organizations aiming to improve the interface and exchange of knowledge between the supply and demand sides (i.e. technology transfer, innovation centres, research mobility programs).
- Supportive infrastructure: educational systems, availability of risk capital, strategic intelligence, material and immaterial infrastructures, match between supply and demand in the labour market, level of management capacity of firms, relations between employers and employees, etc. (Smits & Kuhlmann, 2003, p. 7).

In the above description, government, governance, and policies are subsumed in the list of institutions and functions mentioned.

2.1.2 Triple Helix model

Etzkowitz and Leydesdorff say that the focus of the Triple Helix model is the “network overlay of communications and expectations that reshape the institutional arrangements among universities, industries and governmental agencies” (Etzkowitz & Leydesdorff, 2000, p. 109). This statement is further explained by Leydesdorff and Meyer: “The Triple Helix model tries to capture the dynamics of both communication and organization by introducing the notion of an overlay of exchange relations that feedback on the institutional arrangements” (see Figure 5d) (Leydesdorff & Meyer, 2003, p. 196).

Etzkowitz and Leydesdorff formulate four models of tripartite relations. In Figure 5a we can observe a statist model in which the relations among university and industry are regulated by the State. In Figure 5b, we can see a laissez-faire model, as Etzkowitz and Leydesdorff call it, in which each sphere represents an institutional sector, with strong borders separating each one and relations that may occur between the spheres. In Figure 5c they represent the Triple Helix model, which “is generating a knowledge infrastructure in terms of overlapping institutional spheres, with each assuming the role of the other and with hybrid organizations emerging at the interfaces³⁰. In Figure 5d we can see three strands, representing each sector, and how they can relate between themselves and develop communications, networks and organizations (Etzkowitz & Leydesdorff, 2000, pp. 111-112).

³⁰ Recent literature has addressed these hybrid or boundary organizations in S&T systems (see for instance Atkinson-Grosjean, 2002; Atkinson-Grosjean, House, & Fisher, 2001; Guston, 1999).

Figure 5: Triple Helix configurations

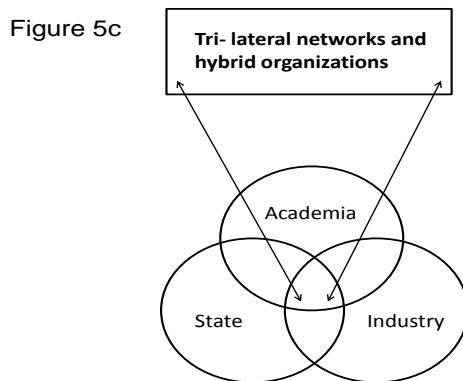
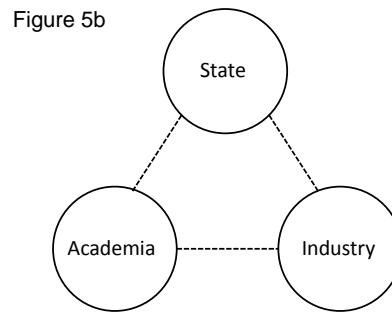
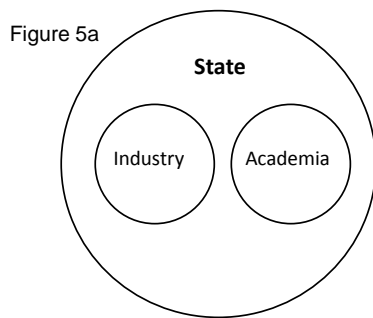


Figure 5d

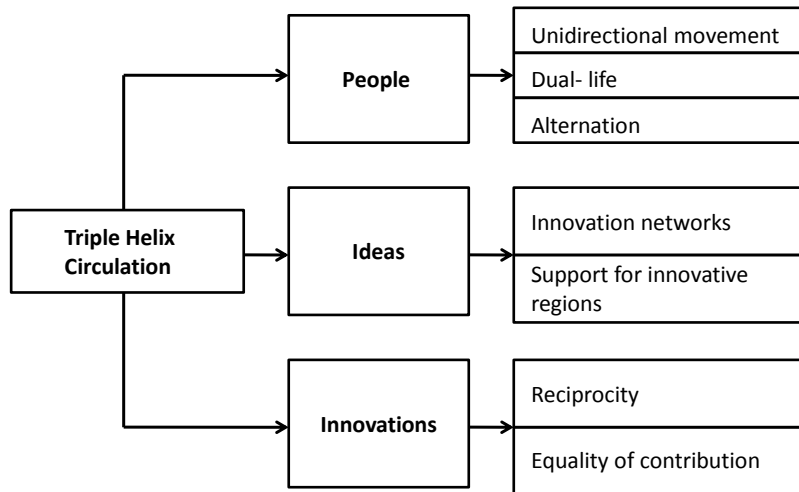


Source: Etzkowitz and Leydesdorff, 2000.

The focal point of the Triple Helix model is communication -interactions between actors- which is exemplified as the “flow of blood in the arteries of the circulatory system” (Dzisah & Etzkowitz, 2009). According to Leydesdorff and Meyer, the focus is "communication as the driver of systems of organized knowledge production and control" (Leydesdorff & Meyer, 2003, p. 196). According to Dzisah and Etzkowitz, what is being communicated are ideas and policies, and the three core elements of the triple helix circulatory system are people, ideas and innovations (see Figure 6) (Dzisah & Etzkowitz, 2009, p. 2). The authors do not provide a clear explanation of all the descriptors, or sub-elements, as they name them. Indeed the ones that are better explained are related to the circulation of people, which I will explain in the next paragraph. Regarding innovation networks, supposedly ideas circulate and collaboration

occurs; however it is not clear why they include innovative regions, unless they are thinking about best practices. Finally, reciprocity and equality of contribution are mentioned as crucial factors needed for collaboration and innovation.

Figure 6: Triple Helix Circulation - the case of innovations

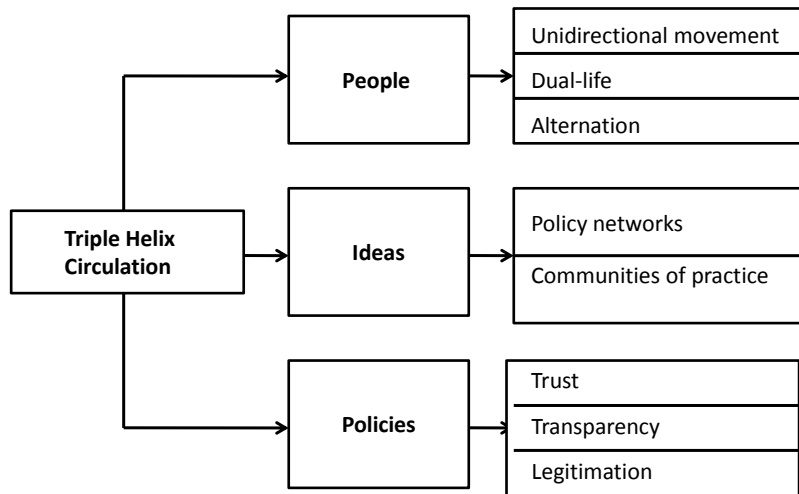


Source: Dzisah & Etzkowitz, 2009.

For the purpose of this thesis, more emphasis will be placed on policy diffusion rather than on innovations and knowledge dissemination, so an adaption of the figure below is proposed; instead of focusing on innovations the Triple Helix circulation focal point will be “policies”. Besides, the descriptors of “ideas” are changed. Regarding the circulation of people, the three possibilities described by the authors - unidirectional movement, dual-life and alternation - correspond perfectly to the Colombian case. Lateral mobility, or revolving door, is very frequent in Colombia, from both the business world and the academia to the government. This would be the case of alternation, and sometimes dual-life, whereby they keep both positions. In developing countries, circulation among Triple Helix actors certainly occurs, since many individuals wear “different hats”,

belonging to various boards and advisory councils, representing formally or not their institution, region, or academic discipline.

Figure 7: Triple Helix Circulation - the case of policies



Source: Prepared by the author, based on Dzisah & Etzkowitz (2009).

In the case of ideas, information flows through various networks, which could be described policy-networks and communities of practice. Policy-networks can be defined as “a set of relatively stable relationships which are of a non-hierarchical and interdependent nature, linking a variety of actors who share common interests with regard to a policy and who exchange resources to pursue these shared interests, acknowledging that co-operation is the best way to achieve common goals” (Borzel, 1997, p. 1). The concept of policy networks can be used from two standpoints: as a form of governance or as a typology of interest intermediation. Borzel argues that the concept from the governance school is narrower and generally applied in the field of public policy. For the purposes of this study, no distinction will be made between the two perspectives of the concept, since in many ways both are present in research and innovation systems.

The concept of communities of practice understood as groups of workers (people) informally bound together by shared experience, expertise and commitment to a joint enterprise (Gertler, 2001), is an interesting concept to apply for the purposes of this study, since it highlights communication between actors (i.e. councillors of PNCyT) that are bound together and framed by a joint interest.

Finally, the formulation and negotiation of policies should be based on trust and transparency, elements that contribute to legitimizing the processes of policy formulation and implementation (Santos-Pereira, 2004). The focus of this thesis, as mentioned above, is not the content of STI policies, but the institutional framework in which they are negotiated and implemented, which determine their effectiveness. As Stein and colleagues say, the issue at stake is not so much “choosing the right policies from a technical standpoint as negotiating, approving, and implementing them in a way that is conducive to their political and their effective application” (Stein, et al., 2006). The viability of policy proposals has more to do with legitimacy than with their technical correctness, as they argue.

The diagram above provides a framework to characterize the relationships among the various actors of the Colombian SNCTI, especially between Colciencias and the programmatic councillors, to track information flows (tracking people, ideas and policies), and to identify roles, perceptions and characteristics of the main actors. The descriptors propose will guide us the analysis of the circulation of people, ideas and policies in the Colombian SNCyT.

Similarly to the *a priori* or *ex-post* concepts of the NSI, mentioned in the section above, there is a discussion of the role that the Triple Helix model plays in developed and developing countries. In developed countries it is an empirical model which describes how these actors interact. In the latter, it is a normative model that countries try to apply or copy by organizing the main components, assuming that the main elements exist (Dzisah & Etzkowitz, 2009, p. 4). The challenge in developing countries is to make the components work together, to cooperate, since they tend to work in isolation.

The concept of a network is mentioned but not deeply discussed from a sociological point of view in the literature on innovation systems and the Triple Helix. Regarding innovation networks, it is acknowledged by the literature that innovation is becoming an increasingly complex activity, mainly because it requires the integration of many resources and knowledge coming from within and outside the firm (Kuppers & Pyka, 2003), and it is in this complexity that networks emerge. Studies on innovation networks focus on how knowledge is created and appropriated, how innovations are produced, and how they are diffused within the society. However, little is known about networking as such, what is different and novel from other forms of social organisation, what kind of interactions occur, what are the coordination mechanisms, etc. Some of the most recent studies about innovation networks are based on theories of complexity and self-organization - which come from natural sciences - and generally, empirical research uses complex, mathematical constructs (see for instance Deroian, 2002; Pyka & Kuppers, 2003). Generally, studies of innovation networks lack a strong theoretical basis despite the long tradition of network theory (Kuppers, 2003). Taking into consideration the above, for understanding research and innovation systems as communication systems it is necessary to explore network theories, and move away from STP studies.

2.2 Network theories

As an introduction to the network literature, I have identified various approaches which seem important for this research, in particular, social network analysis, social capital, and actor network theory. The term network is widely used in many different settings and in various fields and disciplines, making it difficult to establish a clear conceptualization or definition of the term, which results in a loss of its analytical power. As Thompson says “it has become a *word* rather than a *concept*” (Thompson, 2003, p. 2)³¹. The notion of network can be understood as a metaphor, a method, and a theory. The different approaches

³¹ Emphasis in the original text.

presented below will explain these different perspectives on networks. In this sense, Thompson proposes that networks should be understood as theoretical and analytical devices, as specific practices of social organization and coordination. In his own words: “Networks are both a conceptual category or tool of analysis *and* an object of analysis in the form of an actual mode of coordination and governance” (Thompson, 2003, p. 6).

Cressman notes that “networks can be considered both form and process. On one hand, a network refers to a particular architectural form, or organizational structure, wherein people and institutions (among other entities) interact. On the other hand, the term network can also be considered a verb, a process that occurs within the networks”, where networking occurs. Both dimensions are inseparable (Cressman, 2009b, p. 11).

Network theory faces the traditional structure/agency dualism of social sciences, in the words of Jones and colleagues: “Network scholars can be broadly divided in those who favour structural explanations in which the social systems as a whole is pre-eminent over individuals and, secondly, those who consider human action to be the key explanatory factor in the formation of networks” (Jones, Conway, & Steward, 2001, p. 11). These authors, commenting on Giddens³² and his definition of structuration, note that social actors draw on rules and resources in their day-to-day social activity and, in doing so, this recursive activity constantly recreates the structural properties that provide the framework for everyday social practices. Finally, they affirm that “networks cannot be studied as objective social structures which are independent of human agency” (Jones, et al., 2001, p. 11). This argument is reinforced by Conway, who says that “social systems are purposive entities that can be amended, dissolved and reconstructed through the action of their participants” (Conway, 2001, p. 92).

³² Giddens, A. (1984). *The Constitution of Society: Outline of the Theory of Structuration*. Polity, Cambridge.

Rogers³³ identifies two main research traditions of network research: relational and structural. “Relational network analysis essentially focuses on the pathways of networks and identifies the groups of individuals among the members of the network. In contrast, structural analysis focuses on patterns of similarity in relational configurations and identifies ‘blocks’ of actors” (as cited in Conway, 2001, p. 86). Conway further argues that in the relational approach, structure grows out of persistent patterns of communication rather than structure prescribing how individuals should communicate.

In the Colombian case, the agency-structure dichotomy may help us to determine what is dominant, if the legal framework and the rules and norms imposed by Colciencias to the councils, or the everyday practice. Besides, it is not clear if a relational or a structural approach will provide a better description of the situation. Certainly the legal and regulatory frameworks of the SNCyT will lead us towards a structural analysis; however, I doubt that one model of communication and interaction alone can be applied to all the bodies (programmatic councils and departmental commissions). The survey will allow observing these differences.

Social network theory encompasses three approaches, depending on the methodological tools used: network as a metaphor, network mapping, and network analysis. The first has a symbolic orientation and concentrates on qualitative aspects. Network mapping uses graphical tools to describe network’s relationships, and the last is a mathematical approach based on complex statistical methods. Network analysis has become the predominant paradigm within this tradition. Network mapping can be seen as an intermediate point between the other two extremes (metaphorical vs. mathematical) (Conway,

³³ Rogers, E. (1987) “Progress, problems and prospects for network research: Investigating relationships in the age of electronic communication”, paper presented at the VII Sunbelt Social Networks Conference, Florida, 12-15 February.

2001). In this respect, Wellman says that “we dream in graphs and we analyze in matrices³⁴” (Wellman, 2003).

Wellman and Berkowitz are more radical, saying that network analysis is neither a method nor a metaphor, but a fundamental intellectual tool for the study of social structures. Sanz-Menéndez disagrees partially with this position, as he says that social network analysis is not a new paradigm within social sciences, that it is method and a set of techniques, which help to connect actors with social structures that result from the relationships established by those actors (Sanz-Menéndez, 2003, p. 21).

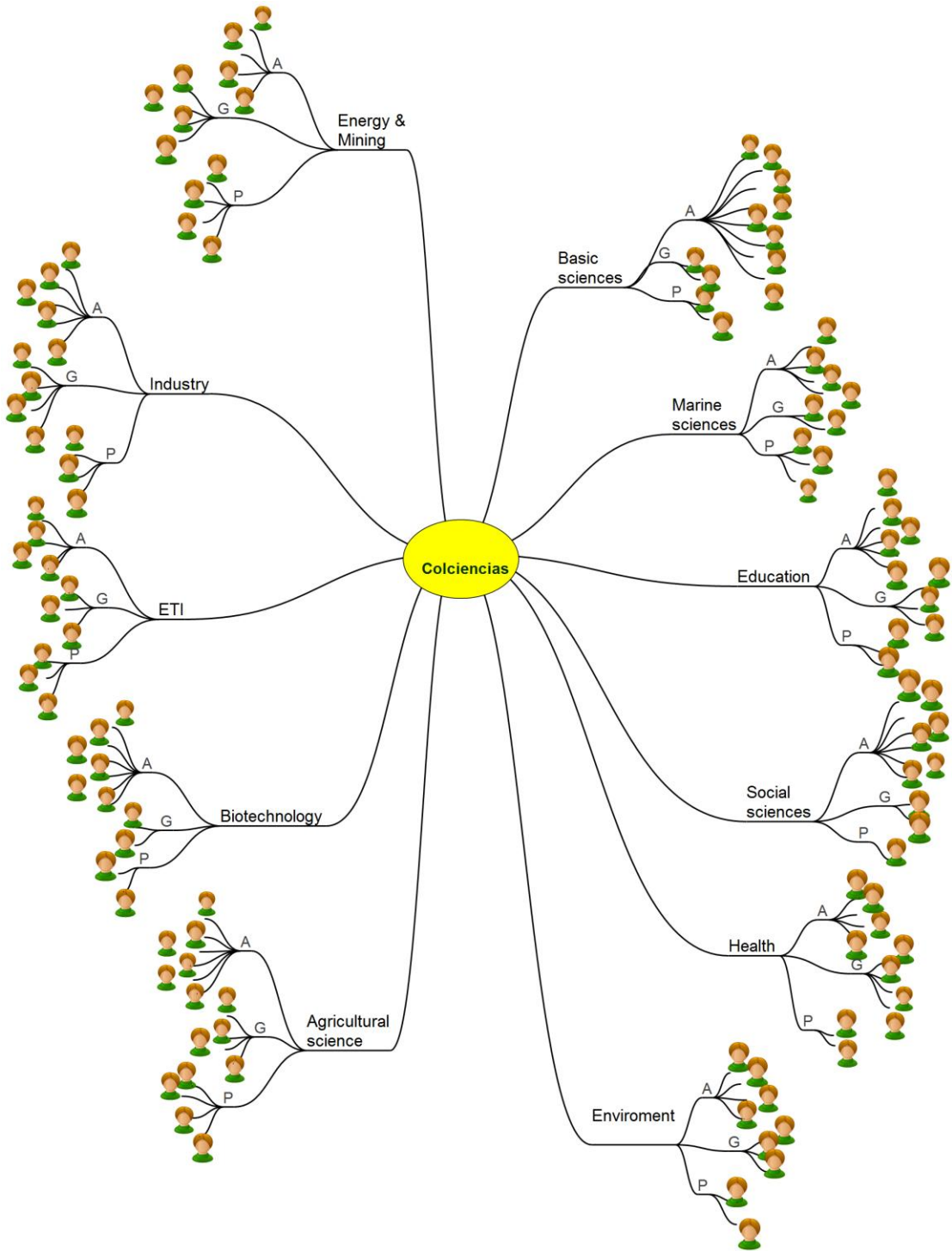
For the purposes of this study, the network concept will be used mainly as a metaphor and an attempt to make a map of the Colombian SNCTI, which can be *a priori* represented as a network (see Figure 8 below), identifying various nodes: Colciencias, the programmatic S&T councils (CPNCyT), and individual actors (researchers, entrepreneurs, and government officials who are members of each council³⁵). The web survey will allow to describe the flows of information that circulate among the nodes and the actors and the use they give to that information; however, it will not be possible to determine the strength of the ties. This type of network could be assimilated to “hierarchical networks” as Burt defines them as large, sparse networks anchored on a central contact, where ties are sustained by the manager or strategic partners, and it is associated with successful outsiders and unsuccessful insiders (Burt, 2000, pp. 407-408). In the case of the Colombian SNCTI, Colciencias is the central contact of the network, and based on the interviews and the survey it will be possible to determine if the

³⁴ In their own words: “[Social scientists] analyze the ordered arrangements of relations that are contingent upon exchange among members of social systems. They map these structures, describe their patterns (often using a set of tools often derived from mathematical graph theory), and seek to uncover the effects of these patterns on the behaviour of the individual members of these structures – whether people, groups, or organizations. [...] Rather than beginning with an *a priori* classification of the observable world, they begin with a set of relations, from which they derive maps and typologies of social structures. Thus they draw inferences from whole to parts, from structures and relations to categories and from behaviours to attitudes” (Wellman & Berkowitz, 1988, p. 3)

³⁵ The graph presents the current composition of each council, showing the members from every sector: academia (A), industry (I), and government (G). In total there are 118 council members (not including Colciencias managers), from which 78 are researchers or entrepreneurs.

performance and success of the SNCyT depends on the councillors, as outsiders, or not.

Figure 8: The Colombian SNCTI as a set of networks: Colciencias and the CPNCyT



Source: Prepared by the author.

Conway proposes categorizing networks as informal or formal organizations. However, in a report done for the European Commission, the authors state that networks are heterarchical by nature, not hierarchical, not based on bureaucratic or administrative authority (Lundvall & Borrás, 1998). Formal structures can be seen in organizational charts and job descriptions. In contrast, informal or emergent networks refer to informal relations that emerge from these prescribed patterns of interaction. Formal and informal organizations can be characterized using a series of dimensions, such as the structure of the organization (origin, rationale, and stability), how influence is exerted, the communication channels and networks used, and the basis for interaction (Conway, 2001). Informal organizations are supposed to be social structures that facilitate information and knowledge sharing. In his own words: “Informal networks are seen as an important device for promoting communication, integration, flexibility, and novelty, within and between organizations. They are viewed as structures that supplement, complement and add value to formal organizations” (Conway, 2001, p. 82). Within informal structures Conway further distinguishes between informal organizations and social organizations, the former task-related, the latter non task-related.

Everett Rogers says that a common principle in human communication is that the transfer of ideas occurs more frequently between people who are alike or homophilous (Rogers, 1995). He defines **homophily**³⁶ as the degree to which pairs of individuals who interact are similar in certain attributes, such as beliefs, education, and social status. The communication between equals is more frequent because it is more effective and rewarding when the source and receiver are homophilous³⁷. In a different context – speaking of innovative

³⁶ The term homophily derives from the Greek word *homoios*, meaning alike or equal. Thus, homophily literally means affiliation or communication with a similar person (Rogers, 1995).

³⁷ Rogers refined this proposition, including the concept of empathy, defined as the ability of an individual to project him or herself into the role of another. He noted: “more effective communication occurs when two individuals are homophilous, unless they have high empathy” (Rogers, 1995); in other words, unless they trust each other. Thus the concept of empathy is in some way related to trust (among the members of a research and innovation system), which is a prior condition to social capital building.

learning regions - Gertler emphasizes similar features for information and knowledge sharing:

Transmission is best shared through to face-to face interaction between partners who already share some basic similarities: the same language, common codes of communication, shared conventions and norms, personal knowledge of each other based on a past experience of successful collaboration or informal interaction. These commonalities are said to serve the vital purpose of building trust between partners, which in turn facilitates the local flows of tacit knowledge between partners (Gertler, 2001, p. 10).

The European Commission states that “network relationships are based on a number of key social and psychological factors, such as: reciprocal exchange relationships among partners; trust in the integrity of partners; belief in the reputation of partners as persons of conscience; understanding of need for openness and willingness to learn; a personal disposition that is inclusive not exclusive; a political disposition that is empowering not elitist; shared customary conventions of rules of the game” (European Commission, 1999, p. 105).

Social capital literature is of major importance for the purposes of this thesis, because social networks cannot be separated from social capital. Social capital can be understood as an outcome of social networks, as assets in a network, or as resources embedded in a network. Burt says that social capital is a potent technology (network analysis) and a critical issue, which allow us to describe why certain people and organizations “perform” better than others (Burt, 2000, p. 346)³⁸. Social networks can be seen as a major resource for building social capital, and as carriers of social capital. Lin states that “social capital is captured from embedded resources in social networks”, which is his fundamental argument for building a network theory of social capital (Lin, 2001, p. 3). Cathleen Johnson provides a simple approach to the interaction between social networks and social capital:

- Social capital is the value of social obligations or contacts formed through a social network.

³⁸ Emphasis added.

- Social networks are the medium through which social capital is created, maintained and used (Johnson, 2003, p. 3).

The origins of this literature can be traced back to Bourdieu, Coleman and Putnam. There is no single definition of social capital, since literature has been produced in different fields. Some of the most common definitions are:

- “Social capital refers to features of social organization, such as norms, trust and networks, that can improve the efficiency of society by facilitating coordinated action” (Putnam as cited in Burt, 2000).
- “Social capital is the sum of resources, actual or potential, that accrue to an individual or group by virtue of possessing a durable network of more or less institutionalized relationships of mutual acquaintance and recognition” (Bourdieu as cited in Burt, 2000).
- [Social capital is the] “accumulation of collaborative linkages that have been built among the members of a society, within what their organizational framework allows. Supposedly, the linkages have certain degree of permanency, therefore they can be accumulated” (Jaramillo & Forero, 2001).
- [Social capital consists of] “investment in social relations by individuals through which they gain access to embedded resources to enhance expected returns of instrumental or expressive actions” (Lin, 2001, pp. 17-19).

According to Nan Lin, the notion of social capital contains three ingredients: resources, embedded in a social structure; accessibility to such social resources by individuals; and use or mobilization of such social resources by individuals in purposive actions (Lin, 2001, p. 12). In this sense, and in his own words, “social capital is more than mere social relations and networks; it evokes the resources embedded and accessed” (Lin, 2001, p. 14). Thus, the analysis of social capital should focus on the valued resources (e.g. wealth, power, and status), which in the case of the Colombian SNCyT could be power or influence, status, and information.

The two streams within social capital literature refer to who can appropriate the benefits derived from the social network: the individual or the group. According to Lin, the premise behind social capital is that if you invest in

social relations you expect returns. The profits that an individual can expect or receive are: to facilitate the flow of information, to exert influence on agents, to certify individual's social credentials, and to reinforce identity and recognition (Lin, 2001). These factors are included in the survey conducted with programmatic councillors, attempting to identify the principal gains they obtain or perceive from participating in the SNCyT.

Complementary to social networks literature, the sociology of science and technology has a group of scholars³⁹ who have developed **Actor Network Theory (ANT)**. Several reasons could be mentioned to include ANT as an input for understanding scientific and technological development in general, and science and innovation systems in particular⁴⁰. First of all, because it recognizes that a network is composed of human and non-human beings⁴¹; it constitutes a seamless web. Networks are composed of people, theories, technical devices, political institutions, policies, natural environment; all equally important heterogeneous elements that must be considered 'symmetrically'. Secondly, ANT academics define a network as the sum of interactions - in a very local and practical locus (Latour, 1999) - rather than as the congregation of specific actors. ANT scholars affirm that they can obtain more by following circulations than by defining entities. As said above, one of the weaknesses of the systems of innovation approach is that it concentrates too heavily on the actors and not enough on the interactions between those actors. Below, Callon's explanation of the importance of the flows with respect to the frameworks:

What needs to be explained is not the fact that, despite the market and against it, person-to-person interaction has to be developed in order to produce shared information. The evidence is the flow, the circulation, the connections, the rareness is the framing (Callon, 1999, p. 186).

The case under study –drawing on the Triple Helix circulation mentioned above- focuses on people, ideas and policies as components of the SNCTI. A

³⁹ Renowned ANT scholars include Bruno Latour, Michel Callon, and John Law.

⁴⁰ ANT attempts to "open the black box" of science and technology by tracing the complex relationships that exist between government, technologies, knowledge, texts, money and people. [...] Methodologically, ANT approaches "science and technology in the making" as opposed to "ready-made science and technology" (Cressman, 2009b, pp. 2-3).

⁴¹ Or as they have been labelled: animate 'actors' and inanimate 'actants'.

CPNCyT resembles an actor network, taking into consideration several elements, such as: various people representing different sectors assembled within the council; their performance is framed by the SNCTI and its rules; they bring their disciplinary, theoretical, regional, political, and institutional backgrounds; and there are technical artefacts such as the processes and information platforms (ScienTI) provided by Colciencias⁴². Although, I will not be able to follow the actors and actants, so it will not be possible to describe the functioning of the councils as an actor network. However, one of the objectives of the web survey is to observe the dissemination and adoptions of policies, ideas and information from Colciencias to programmatic councillors and back.

One of the critiques to ANT is that it does not deal with the power issue in itself, except when distinguishing between macro and micro actors⁴³. ANT scholars affirm that no actor is bigger than another except for the means of transaction, in other words, in their ability to build stable relationships. ANT takes into account social power (performative power) but not economic power. Callon and Latour note, in this respect, that “there are macro-actors and micro-actors, but the difference between them is brought about by power relations and the construction of networks” (Callon & Latour, 1981). Another critique relates to performative power. As Cressman says, “this is a serious problem for a theory that is best understood as something that is *performed* rather than that is *summarized*”⁴⁴ (Cressman, 2009b, p. 1).

I would like to quote Callon (1987) on his definition of Actor Network Theory:

The actor network is reducible neither to an actor alone nor to a network. Like networks it is composed of a series of heterogeneous elements that have been linked to one another for a certain period of time. (...) The actor network should not be confused with a network linking in some predictable fashion elements that are perfectly well defined and stable. (...) An actor network is simultaneously an actor

⁴² See section 3.4 for a description of the information systems.

⁴³ Macro actors are institutions, organizations, social classes, parties, and nation-states; while micro actors are individuals, groups, families.

⁴⁴ Emphasis in the original text.

whose activity is networking heterogeneous elements and a network that is able to redefine and transform what it is made of (Callon, 1987, p. 93).

According to the definition above, networks for ANT scholars cannot be mapped in the way that social network theories attempt to do (see above), because the comprehension of the network is done through action, observing the roles performed by various actors, and how they affect each other. “Size, power and influence are an effect that is performed by other actors, not a permanent condition” (Cressman, 2009a, p. 5)

ANT could be criticized for not considering the social, cultural and political environment where scientific and technological development takes place. ANT scholars disregard the influence of broader social and economic structures of power and interests, as they concentrate on the micro level and neglect the macro level (social structures). However, they argue that since there is no real dichotomy between the macro and micro levels, researchers should focus on the movement. Actor network theory emphasizes the need to focus on the transactions, the movement, the interactions, rather than on the agents or the networks as such. In a research and innovation system, the movements are the connections and interactions between heterogeneous actors, such as people, ideas, policies, information, knowledge, and financial resources, and the functions developed by those actors.

In the next section, the final component of the theoretical framework will be introduced, which deals with institutionalism and principal-agent relationships, applied to research and innovation systems. Up to now, the theories and approaches presented do not take into consideration the special relationships that research councils establish with either government or the scientific community. For understating the dealings between Colciencias, the programmatic councils, and academics, it is important to study this literature.

2.3 Principal-agent theory

Since the focus of the thesis is Colombian S&T institutions and the interactions between various actors, neo-institutional theories were taken into consideration, especially when trying to comprehend the different roles that research councils could play, and the relationships they establish with the scientific community and the government. Within institutional theories, some S&T scholars have applied the principal-agent framework for explaining S&T political and governance issues, which is central to the dissertation.

According to Braun and Guston (2003), principal-agent theory was developed in the perspective of rational choice and transaction cost theory within the framework of new institutional economics, and in the early 1990s was introduced in the context of research policy-making by Braun (1993). The basic logic of this theory is that there is an organization or actor that looks to delegate some of its functions to other actors that seem in a better position to perform them. This relationship is generally not considered from a hierarchical perspective; to a certain extent both sides are autonomous. Guston states that principal-agent (P-A) theory is also known as ideal contracting theory. From his perspective, research grants and contracts are central to the relation between the state and scientists; therefore, this theory should be an essential analytical method for science and technology policy studies⁴⁵ (Guston, 1996, p. 230). The basic exchange is that the principal transfers resources to the agent(s), who should do what the principal cannot.

If the state delegates in scientists to do “science”, it is difficult for the principal/state to know if he is selecting the appropriate agent to do what he wants to be done or if the agent is pursuing its own goals or the principal’s goals. In this sense, most of the papers analyzed deal to a greater or lesser extent with aspects related to delegation, such as contracts, decision-making costs,

⁴⁵ This is the metaphorical social contract of science (Guston, 1996).

monitoring rights and costs, information asymmetry⁴⁶, trust, and social responsiveness (Braun, 1993, 2003; Caswill, 2003; van der Meulen, 1998, 2003).

Principal-agent theory applied to a political rather than an economic context emphasizes different aspects, even if neo-institutionalism is the origin of both. For instance transaction costs are not crucial, but trust of the principal over the agent is vital⁴⁷, and institutional structures are essential, in particular knowing the differences between countries regarding research and innovation systems⁴⁸. According to Guston, P-A theory can be applied to any situation that involves delegation, contracting, or representation. In the case of the Colombian SNCTI, the P-A theory can certainly be applied, since there is delegation of certain functions from Colciencias to the CPNCyT, such as the selection of projects and funding allocation; and representation of scientists in the CPNCyT, as it will be explained in the next chapter.

It is interesting to note that different authors do not have a unique perception of who is the principal and who is the actor in the field of S&T. Moreover, some include a third agent that can be either an intermediary between the principal and the agent, or simply a third party. Below, I present a summary of some of these perspectives.

⁴⁶ Gulbrandsen (2005), making reference to Norway, states that as a small country there is no information asymmetry between the principal and the agent, because the research council personnel may know the research community and the trajectories of the principal investigators quite well. Something similar occurs in Colombia, which has a small research community.

⁴⁷ Generally speaking, these authors emphasize the trust aspect within science from different angles: in the P-A relation, in the peer-review process, and as part of the scientific ethos.

⁴⁸ With respect to S&T policy, the principal could be a ministry, a research council, a funding or granting agency, or a mission oriented agency, which perform similar functions but their portfolio changes and, of course, their position within the government apparatus is different.

Table 2: Principal-agent viewpoints

Authors	Principal	Agent	Intermediary or Third party
Braun 1993	State	Research agency	Scientists
Guston 1996	State	Science	
Van der Meulen 1998	Research funding agencies	Scientists	
Van der Meulen 2003	Policy-maker	Scientists	Research council or funding organization
Braun 2003	Policy-makers	Scientists	
Caswill 2003	Ministry	Research actors	Research funding organization
Gulbrandsen 2005	Research council	Research community	
Slipasæter, Lepori & Dinges, 2007	Government	Research council	
	Research council	Institutions of science	

Sources: Prepared by the author based on Braun (1993), Braun and Guston (2003), Caswill (2003), Gulbrandsen (2005), Guston (1996), Slipasæter, Lepori & Dinges (2007), and van der Meulen (1998, 2003).

For the purposes of this study, van der Meulen's (2003) proposal seems to be the most adequate, since there are three actors: Colciencias, the CPNCyT and researchers (or in general beneficiaries of public funding), where the councils seem to perform the role of mediator between the government and the scientific community. In the Colombian case, Colciencias (principal) plays different roles – policy-making and funding-, and delegates the evaluation and selection of projects to the CPNCyT (agents). But the programmatic councils also act as principals in their relationship with researchers and entrepreneurs (agents). In the words of van der Meulen “the research councils in our case can be seen as a link in a chain of principal-agent relationships” (van der Meulen, 2003).

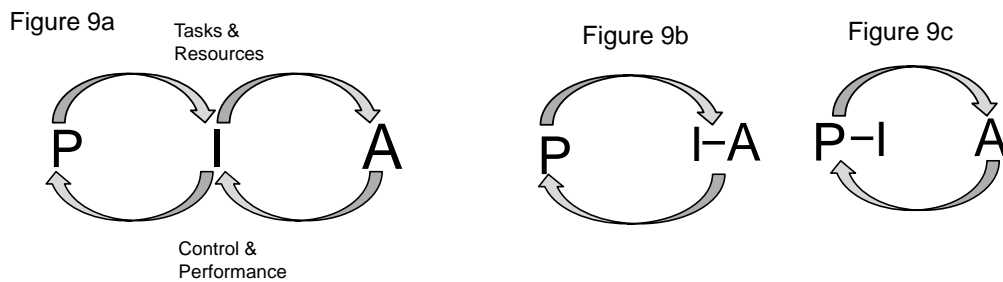
Most of the authors present the P-A relation as a delegation issue, associated with two main problems caused by information asymmetry: moral hazard and adverse selection. These problems, according to Braun and Guston, are based on what new institutional economics calls the “opportunism” of actors: “Actors are self-interested and thus seek to maximise their personal welfare” (Braun & Guston, 2003, p. 303). This occurs despite the fact that both actors are interested in engaging in the relationship, since both obtain benefit; the principal

has something done, and the agent gets some kind of remuneration (e.g. money, social recognition, etc.).

Research councils perform different roles: i) they can access and integrate knowledge more easily because they are closer to the scientific community; and, ii) they allow government to reduce transaction costs by implementing policies. Braun also argues, that the “triadic” structure (principal, agent and third party) establishes improved communication channels between the political and the policy system (Braun, 1993). The question is whether research councils are due to government or scientists, or whether they are the object of political interests or captured by scientific elites⁴⁹. He proposes three types of relations among principal, intermediary and agent, depending on the control of key resources: funds, authority and monitoring privileges. The principal transfers tasks and resources to the agents, and expects control and performance from the agents. Braun’s proposal is similar to van der Meulen’s. The main difference between the configurations (see below) is who retains control over the critical resources. In Figure 9a, the control remains in the government; this is to some extent the more balanced configuration of the three presented. Figure 9b shows a common arrangement with regard to research councils, in which scientists are in control and government transfers the resources, taking into consideration that the councils are very close to the research community via evaluation (peer-review) and monitoring processes. In this case, the main tie is between the intermediary and the agents. Figure 9c shows an arrangement where government defines clear rules of operation for the councils and scientists, even if research councils are involved in certain evaluation activities, follow these rules. In this configuration, the main linkage is between the principal and the intermediary.

⁴⁹ It is worth recalling Salomon (1977), who said that organizations concerned with S&T policy were set up with the purpose of associating the advice of scientists to political decisions, and that they should perform at least three functions: information, consultation and coordination. In this sense, the problems associated with these relationships seem unavoidable.

Figure 9: Configurations between principal, intermediary and agents



Source: van der Meulen, 2003.

Gulbrandsen (2005), drawing on Braun (1998), Guston (1996) and van der Meulen (1998), emphasizes the tensions present in any P-A relation, which are normal and depend on the issues at stake (e.g. project formulation, allocation of funding, autonomy of science, fulfillment of government goals, etc.). He describes them as “normal” since these tensions or frictions are part of the process; they cannot be avoided, they cannot be solved. He characterizes these problems as the product of three aspects related to science policy and funding: i) policy-making as such; ii) selection of projects; iii) control and monitoring (Gulbrandsen, 2005)⁵⁰. These tensions will be explored in the interviews.

The theoretical and conceptual framework presented in this chapter provides the basis for explaining how institutional and individual actors of the Colombian SNCTI establish relationships and constitute networks, the interaction mechanisms they use, and how information is exchanged between them. To summarize Sábato’s Triangle, the Triple Helix model, and the NSI supply the normative framework to explain the Colombian SNCTI, showing the central actors and functions necessary for STI development. Principal-agent theory provides the basis for understanding the relationships between government

⁵⁰ The selection arena is related to the adverse selection problem, and the control arena is related to the moral hazard problem, considered the two typical collective action problems discussed in this literature.

(Colciencias), the programmatic councils and the councillors. And, finally, social capital theory explains how resources circulate in social networks and the outcomes obtained from those interactions.

Let me conclude drawing on each of the theories and approaches presented, attempting to propose what can be observed in research and innovation systems, what flows or circulates in the systems will be the categories and dimensions that I will be analyzing.

Table 3. Circulation in research and innovation systems

<i>Sábato's triangle inter-relationships</i>	<i>Triple Helix (Leydesdorff & Etzkowitz)</i>	<i>Triple Helix circulation (Dzisah & Etzkowitz)</i>	<i>NSI</i>	<i>P-A (van der Meulen)</i>	<i>ANT (Callon)</i>	<i>Social capital (Lin)</i>	<i>Triadic combination (summary)</i>
Financial resources	Networks	People	Financial resources	Resources	People	Wealth	Financial resources
Demand and production of knowledge	Communications	Policies / Innovations	Innovations	Tasks	Policies	Power	Policies
Interchange of personnel	Organizations	Ideas / knowledge	Information & knowledge	Control & performance	Political institutions	Status	Institutions
Policies					Technical devices		
					Theories		

Sources: Prepared by author based on Callon, 1987; Dzisah & Etzkowitz, 2009; Etzkowitz & Leydesdorff 2000; Holbrook & Wolfe, 2000; Lin, 2001; Sábato & Botana, 1968; van der Meulen, 2003

What is presented as the triadic combination – funding, policies and institutions - is my proposal of the categories that I will be looking at when studying the Colombian SNCyT: what circulates between the actors, and the outcomes of those interactions. For instance, regarding social capital the valued resources that are embedded in social networks are wealth, power and status, and the benefits expected are information, influence over agents, certification of social credentials and recognition.

3 THE EVOLUTION OF SCIENCE & TECHNOLOGY INSTITUTIONS AND POLICIES IN COLOMBIA 1989-2008

Policy and models of organization of Science and Technology in Latin American countries have been greatly influenced by the proposals and recommendations of international organizations⁵¹. Four of the most important agencies are: the OAS, UNESCO, the International Development Research Centre (IDRC) of Canada in the early years of science and technology policy; and much later, the Inter-American Development Bank (IADB). For instance, OAS and UNESCO were crucial in promoting the creation of national S&T organizations, mainly known in the region as national councils or “Conacyt”, to support scientific and technological development (Nupia, 2010). The IADB, via international loans, has been highly influential in promoting innovation policy and encouraging the creation of innovation systems.

Looking back and identifying the landmarks in the history of S&T policy and institutions in Colombia, we can recognize five periods which can now be clearly observed, although the beginning and end dates are not precise (see table below). For the purposes of this document and based on other authors (Jaramillo, et al., 2004), the recent history will be divided into four periods: i) pre-1968: before the creation of Colciencias; ii) 1968-1988: the early years of Colciencias; iii) 1989-2000: creation and development of the National System of Science and Technology (SNCyT, for its Spanish acronym); and iv) 2001-2008: the articulation and information were key. A fifth period began in February 2009 with the enactment of the new Science and Technology Law, which modified Colciencias’ status and responsibilities, and changed the name of the System to include the word innovation. It is still too early to know the impact of this new law; however, in the fifth section of this chapter, I will present the most important

⁵¹ See Sebastian (2007) for a short review of the influence of these organizations on the scientific and technological development in Latin America.

changes and the current situation of Colciencias. In the last section will statistics and indicators regarding the Colombian SNCyT will be presented.

Table 4: Landmarks in the development of S&T in Colombia

Pre 1968	1968 - 1988
<ul style="list-style-type: none"> • 1963: UN conference on the application of S&T for development • 1964: OAS conference on S&T policy and planning • 1967: Punta del Este Conference of American Presidents • Latin-American School of Thought of S&T for development • 1968: Fusagasugá conference: basis for creation of Colciencias 	<ul style="list-style-type: none"> • 1970: creation of first master's programs • 1983: IADB - ICFES credit program • 1983: IADB - Colciencias first credit program • 1986: First doctoral program • 1987: International Forum on S&T policy • 1988: S&T Mission
1989 – 2000	2001 – 2008
<ul style="list-style-type: none"> • 1990: Law 29 – S&T law • 1990: Decree 1767, Colciencias was ascribed to DNP • 1991: IADB - Colciencias second credit program • 1991: Decrees 393, 585, 591: creation of the SNCyT, regulation of contract and association models in S&T • 1993: Mission of Science, Technology and Development • 1995: IADB - Colciencias third credit program • 1995: National Innovation System launched • 1996: Law 344, SENA resources to S&T activities • 1999: Creation of the Colombian Observatory of Science and Technology 	<ul style="list-style-type: none"> • 2001: Law 643 created the Health Research Fund • 2001: Publindex launched: index of Colombian scientific journals • 2002: ScienTI platform launched • 2002: World Bank – Colciencias credit for doctoral programs and scholarships • 2003 Law 812, Economic and Social Development Plan, that requires SENA to give money to Colciencias • 2005: Maloka forum: discussion of a new law for S&T started • 2006: Visión Colombia 2019: long term plan for STI • 2008: <i>Colombia Siembra y Construye Futuro</i> – National Research and Innovation Policy

Source: adapted from Jaramillo et al (2004) and updated by the author.

Not all the periods mentioned above are equally important for the purposes of this document, so I will develop the third and fourth periods in greater depth, since the SNCyT was created and developed during those years

(1989-2008), and the system and some of its institutions are the focal point of the thesis.

3.1 Pre 1968: before Colciencias

Even though this period is prior to the creation of Colciencias, this does not mean that there was no scientific activity before then. The first, primarily public, research institutes were created either at the turn of the twentieth century or after the Second World War (Villaveces & Forero, 2007, p. 97). Many of those institutes have survived for many years and others have been transformed or merged with others. Several of the names associated with those early initiatives are: Agricultural Colombian Institute (Spanish acronym, ICA), Technological Research Institute (Spanish acronym, IIT), Nuclear Institute (Spanish acronym, IAN), and National Institute of Health⁵² (Spanish acronym, INS). In addition to public research institutes, some growers associations in the agricultural sector also created specialized research institutes, such as the National Coffee Research Centre (Spanish acronym, Cenicafé). Besides the creation of research centres, several international (mainly North American) technical assistance missions and foundations for development arrived in the country (e.g. Johnson and Currie missions, Rockefeller Foundation, Ford Foundation), oriented towards the promotion of education, training and research (Villaveces & Forero, 2007, pp. 105-106). It is important to note that ICETEX, the Colombian fund for international studies and technical training, was created in 1950 as part of the recommendations given by the missions mentioned above to modernize the state.

As said previously, in Latin America the influence of the OAS, the IDRC and UNESCO were very important to placing S&T promotion and economic development in the public agenda. Back then, several studies and inventories

⁵² Many of these institutes were originally created under different names and later transformed; at present, they are known under the names given above.

were promoted by these organizations in order to have a clear idea of the state of national capabilities⁵³.

This first period is characterized primarily by exogenous factors, such as international and multilateral organizations and the regional movement of science and technology for development, described in chapter one. The Latin American school of thought on science, technology and development had its local “members”, such as Felix Moreno, Captain Alberto Ospina, Pedro Amaya, and Luis Javier Jaramillo, who were influential in the creation and the development of Colciencias, some of them were Colciencias general directors at some point. International influence has remained over the years but under another figure, that is, foreign credits for STI activities. The IADB and the World Bank through the credits granted to Colciencias have been significant orienting research and innovation plans and policy instruments.

3.2 1968-1988: Colciencias, the early years

The second period, which spanned from the creation of Colciencias⁵⁴ until the launching of the National Year of Science (1987-1988), is characterized by the development of endogenous capacities (Villaveces & Forero, 2007), such as the institutionalization of research activity within universities, creation of the first national master’s and doctoral programs, appointment of full time professors, institutionalization of research, and creation of R&D labs, etc. The foundations of the research system were created during this period, although the resources (people and money) devoted to science were meager. Since then, the idea that funding and policy-making should be integrated was put into place, with the

⁵³ See for instance, Chaves, M. (1972). *Aproximación al estudio del sistema científico y tecnológico de Colombia: informe de avance sobre los datos de las primeras 22 entidades de la encuesta* (Approximation to the scientific and technological system in Colombia: Report on a survey to 22 institutions). Bogotá: Colciencias.

⁵⁴ In addition to the creation of Colciencias, the Colombian Institute for the Promotion of Higher Education (Spanish acronym, ICFES) was also launched.

argument that the two complement each other and should be done in an integrated manner (Chaparro, 1978, p. 11)⁵⁵.

Despite the recommendations of prescriptions of movement of S&T for development, these early years were characterized by a weak relationship between economic and social policies and S&T policies, which were dominated by a scientific and academic perspective. This situation is not unique to Colombia, as many other agencies were born close to the academic community.

The principal government actor in the Colombian S&T system has been Colciencias, which has changed its name and nature over the years as well as its place within the state apparatus. Back when it was formed in 1968, its full name was Colombian Fund for Scientific Research and Special Projects “Francisco José de Caldas”⁵⁶ – Colciencias, and was part of the Ministry of Education. At the same time the National Council of Science and Technology was formed, an advisory body of the government that met only twice in 20 years. Colciencias, which was the S&T national granting council, timidly formulated policies, had little importance and, in general, had little visibility and power within the government. It was so “marginal” that even its physical location was far from most of the governmental organizations. The Ministries are located along a major avenue (26th Street), relatively close to the Presidential Palace and the Congress, in an area called the “National Administrative Centre”. Colciencias is located, since the 1980s, in the northern part of the city (134th Street), far from other public agencies, major universities, and R&D labs.

Back then, Colciencias was more autonomous than it is today, but it was isolated from the rest of the government apparatus and interacted rarely with other government agencies. There was neither political nor financial support for scientific and technological activities. Scientific and technological plans were just

⁵⁵ Fernando Chaparro was Deputy Director of Colciencias at the time, and later from 1994-1998, he was Colciencias General Director.

⁵⁶ Francisco José de Caldas lived in the XVIII century; he was a botanist, astronomer, mathematician, geographer, and precursor of Colombian independence from Spain; for many generations of Colombians he is considered a promoter of scientific culture.

an appendix of economic and social development plans, if developed or taken into account at all⁵⁷.

The end of this period is characterized by major efforts to “place” S&T policy at the centre of the economic and social debate. Most of these efforts were promoted from within Colciencias, with the support of universities, the Colombian Association for the Advancement of Science (Spanish acronym, ACAC) and the government. The two most important events of the latter part of the second period were the first foreign credit for S&T (1983-1988) granted by the IADB⁵⁸ and the S&T Mission. The S&T Mission was summoned by the government in 1988 and composed by scientists. Its final report in 1990 provided the foundations for the next period. For instance, it recommended the enactment of an S&T law, the promotion of doctoral programmes, and moving Colciencias from the Ministry of Education to the National Department of Planning (Spanish acronym, DNP). The DNP is in charge of economic and social planning and the national investment budget. In the Colombian state apparatus, it has the level of a ministry and is as powerful as the Ministry of Public Finances.

3.3 1989-2000: The creation of the National S&T System

The third period is certainly the most important in the development of research and innovation in Colombia, considering that new organizational and institutional arrangements were set up and new instruments were developed. The decade of the nineties, in particular the early 90's, was marked by the “*apertura*”, the opening of the Colombian economy to the world. Changes in the

⁵⁷ Some examples of administrations that did not include within their national development plan a section or appendix on science and technology are: Belisario Betancur 1982-1986, and Virgilio Barco 1986-1990, under which Law 29/1990 was enacted. While in the plan of Julio Cesar Turbay (1978-1982) it was the last section of the plan and it is eight pages long. All plans can be downloaded at: <http://www.dnp.gov.co/PortalWeb/PND/PlanesdeDesarrolloanteriores.aspx>

⁵⁸ The amount of the credit was US\$44.5 million. The main objectives were to increase scientific and technological activities; and, to improve the quality of research in terms of objectives, methodologies. All IADB loans given to Colciencias are paid by the National Government, which in fact means that are public money.

S&T system were accompanied by changes in the economic model⁵⁹. One cannot argue that the *apertura* brought together the need for S&T policy, but certainly because of the opening of the markets, firms saw the need to invest in technology, either imported (primarily) or developed nationally. The productive sector invested heavily in modernizing machinery and equipment in the first half of the decade (Durán, et al., 1998; Durán, Ibañez, Salazar, & Vargas, 2000).

In 1990, after a long lobbying campaign in Congress, the Science and Technology Law (Law 29) was issued. The law dictates general provisions for the promotion of scientific research and technological development and also enables the executive branch to change the structure and the functions of public institutions that promote or carry out scientific and technological activities performed. As the law needed to be regulated⁶⁰, a set of decrees were issued in 1991⁶¹. The most important of these created the Colombian SNCyT, re-launched the National Council of Science and Technology (CNCyT), and re-organized Colciencias, which was given a clearer role in policy formulation and depending on the DNP⁶².

The SNCyT was conceived as an open system, non-exclusionary, which incorporates all programmes, strategies, and activities performed by various agents (public, private, organizations and individuals, etc.) (Colciencias, 1992, 1991)⁶³. Below is the original graph of the structure of the Colombian S&T System, which shows the different coordinating and directive bodies. Even if the

⁵⁹ The early 1990s in Colombia can be characterized as a period of major changes, in many areas: economic, political, social, and legal. A student movement in the late 1980s promoted the creation of a Constitutional Assembly, which was elected in 1990 with a varied composition (traditional political parties, an ex-guerrilla group, indigenous people, etc). The Assembly enacted a new Constitution in 1991, which has influenced many aspects of the Colombian society.

⁶⁰ Soon after the enactment of the S&T law, Colombia had a presidential election. It is said that the original design of the SNCyT was not implemented (developed under Barco's administration); instead incoming President Gaviria appointed a new Colciencias' management team, commissioned to develop a novel model.

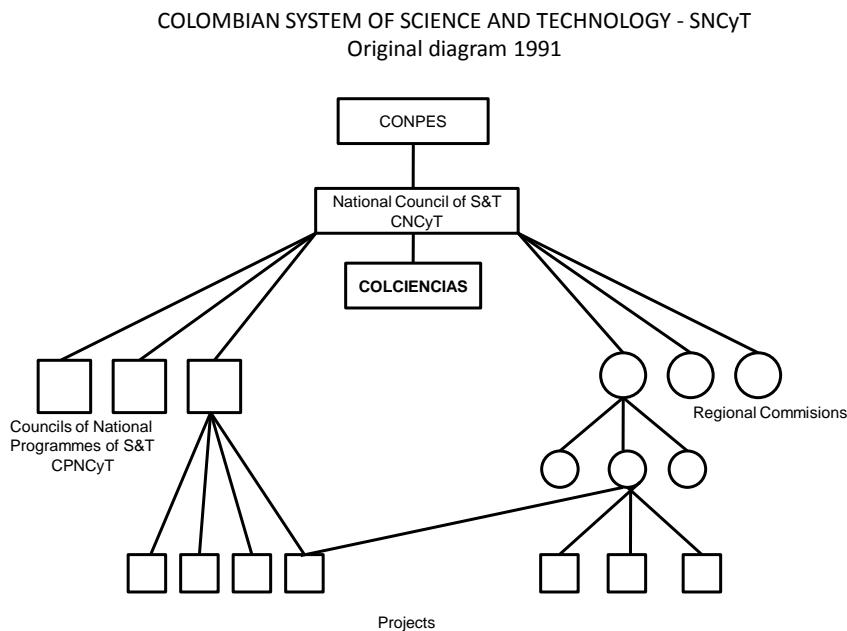
⁶¹ Decrees 393 and 591 provided the legal framework for public-private association and contracts for the development of S&T activities. Decree 585 defined the objectives, functions and institutional arrangements of the National System of Science and Technology (SNCyT). These three decrees have remained over time; others have been derogated by other laws and decrees.

⁶² Like the NRC depends in Industry Canada.

⁶³ Most of the description of the SNCyT that follows is based on the law and the decrees, the books just referenced, and my own knowledge of the system.

system has two main components, the programmatic councils and the regional commissions, only one has been central: the CPNCyT. This graph is quite simple compared to the ones developed subsequently, and it is interesting to note the focus on projects rather than on institutions that develop projects.

Figure 10: Representation of the Colombian SNCyT 1991



Source: Colciencias, 1991.

The structure and composition of the system and its various councils is not new in itself; previously, Colciencias functioned by S&T programmes, and some councils were actually functioning (e.g. marine investigation). The design of the system was participatory and took into account some of the recommendations made by the S&T Mission mentioned before. The system is organized in three levels: national, regional (geographic), and sectoral (programmatic), and at each level there are councils where the coordination of S&T policy should take place. All of these bodies are collegiate corps based on Sábato's Triangle model, which integrates three institutional spheres: government, academia and industry⁶⁴. Furthermore, the axis of the institutional reform was the setting-up of a legal

⁶⁴ The idea of using the Sábato's model was discussed at the moment; it is not *a posteriori* finding that the tripartite model corresponds to Sábato's Triangle (Villaveces & Forero, 2007, p. 124).

framework that allowed the association between the state and private organizations for S&T activities.

As an example of the tripartite arrangements put into place, the CNCyT is composed of:

- Head of National Department of Planning or his/her delegate, who acts on behalf of the President.
- Minister of Education or his/her delegate.
- Minister of Commerce, Industry and Tourism or his/her delegate.
- Minister of Agriculture or his/her delegate.
- Rector of the *Universidad Nacional de Colombia* (national public university) as principal and the rector of a public university as a substitute.
- The rector of a private university (principal and substitute).
- One representative of the scientific community sector (principal and substitute).
- One representative of the business sector (principal and substitute).
- One representative of the Regional Commissions of S&T.
- Director of Colciencias, without vote.

The system is structured around science and technology programmes, which are understood as broad areas of scientific and technological problems and are considered the main components of the system. The domain of the programmes is either a field of S&T or an economic sector. Seven national programmes were created by law and, a few months later, the national council created four more. At present, the eleven national programmes of science and technology are:

- National programme of basic sciences.
- National programme of social sciences and humanities.
- National programme of S&T health.
- National programme of agricultural S&T.

- National programme of biotechnology.
- National programme of environmental and habitat S&T.
- National programme of research in energy and mining.
- National programme of technological and industrial development and quality.
- National programme of electronics, telecommunications and informatics.
- National programme of marine S&T.
- National programme of scientific studies of education.

At the regional level, the SNCyT has changed its coordination scheme. Six regional commissions were initially created that followed the economic and social planning organization. The regions were conceived as groups of several departments⁶⁵ (the sub-national level in Colombia). When the planning commissions disappeared, so did the S&T commissions. Subsequently, the departments began to create their own S&T Councils, known as Codecyt. Today every Colombian department has its own council, which means that there are 32 Codecyt, although not all of them are operational. In some cases, the local governments have created their own funding mechanisms and instruments and, therefore, have greater power over the definition of their S&T agenda and, thus, do not depend entirely on Colciencias.

The councils of the national programmes have between seven to ten members, of which three to five are researchers, at least two are from the business sector, and two to three are from government. Its normal composition is as follows:

- Head of National Department of planning or his/her delegate⁶⁶.
- Director of Colciencias or his/her delegate.
- Representatives of the scientific community and the productive sector.

⁶⁵ Equivalent to the provinces in Canada.

⁶⁶ Usually, the head of the respective technical division.

- Minister of the area, if it exists, or his/her delegate.
- Directors of governmental institutes related with the area.

Councillors from the research community and the productive sector are appointed by the National Council of S&T, after presentation of candidates selected by Colciencias. These people do not act in representation of any institution or region; they are elected on the basis of merit, not nominated by universities, R&D centres, academies of science, or producers associations, etc. Their selection is an acknowledgement of their careers. Councillors are *ad hoc* positions and they work *ad honorem*.

The functions of all the agencies mentioned above will not be described below, only those of the programmatic councils which are the focus of this research. Their main functions are:

- To approve the policies of research, promotion, information, communication, regionalization, training and funding of the programme.
- To coordinate the development of the S&T programme strategic plan, after an extensive process of national and regional consultation.
- To promote government and private fund raising.
- To allocate financial resources for different projects, after an evaluation process coordinated by Colciencias.

It is important to mention that Colciencias has always used the peer-review system for the evaluation of research and innovation projects. This means that councillors are not in charge of evaluation as such, they participate in the process, selecting the evaluation committees and, based on the evaluations they receive, choosing the projects to be financed.

None of the agencies mentioned above constitutes in itself a new administrative structure, i.e. a public office. With the exception of Colciencias, they are only coordinating mechanisms. The secretariats of the programmes are

exercised by Colciencias alone or in conjunction with another governmental institute. The executive branch of the state is represented in virtually every instance of the SNCyT, in order to ensure that any decision taken is supported by the government and that it will fund research and development activities. Although Sabato's Triangle model places research promotion agencies within the scientific and technological infrastructure, in the case of Colombia it is obvious that Colciencias, as head of the SNCyT, is the main actor within the government and cannot be considered in any other vertex.

Due to the structure of the SNCyT, it is comprehensible that decision-taking bodies (the national council, the programmatic councils, and the regional commissions) are highly dependent on Colciencias because they are not formal organizations, they do not have their own personnel, that is, not Colciencias staff (councillors are ad-hoc positions), and they do not administer money⁶⁷. However, the model or relationship is not problematic in and of itself, since the councillors take an oath to perform a public function for the country, and directors of Colciencias comply with the decisions taken by the councils. This is quite unique, since councillors are not civil servants but they can allocate public resources. In view of the above, programmatic councils can certainly not be considered equal to the research councils that exist in other countries. Even though Colciencias is a formal governmental organization, it was necessary to define the "rules of the game" that allow the SNCyT to function. As Villaveces and Forero⁶⁸ say:

Besides providing a legal entity of scientific research in Colombia and giving a formal structure to the national system of science and technology, as the law had ordered, there was the creation of an institutional framework of formal legal possibilities, a complementary group of informal institutions, and a series of collective constructions of social consensus (Villaveces & Forero, 2007, p. 119).

⁶⁷ The case of the regional commissions in the past, and the current departmental councils is a little bit different, because no personnel of Colciencias actually support the functioning of each body, even if there is a Colciencias' representative. At present each department has to define the structure of the councils, who is coordinating it, and the funding does not provide completely from Colciencias.

⁶⁸ Clemente Forero was General Director of Colciencias between 1990 and 1994, during the setting up of the SNCyT; and, José Luis Villaveces was deputy director for scientific and technological programmes in the same period, and later (2000-2001) returned.

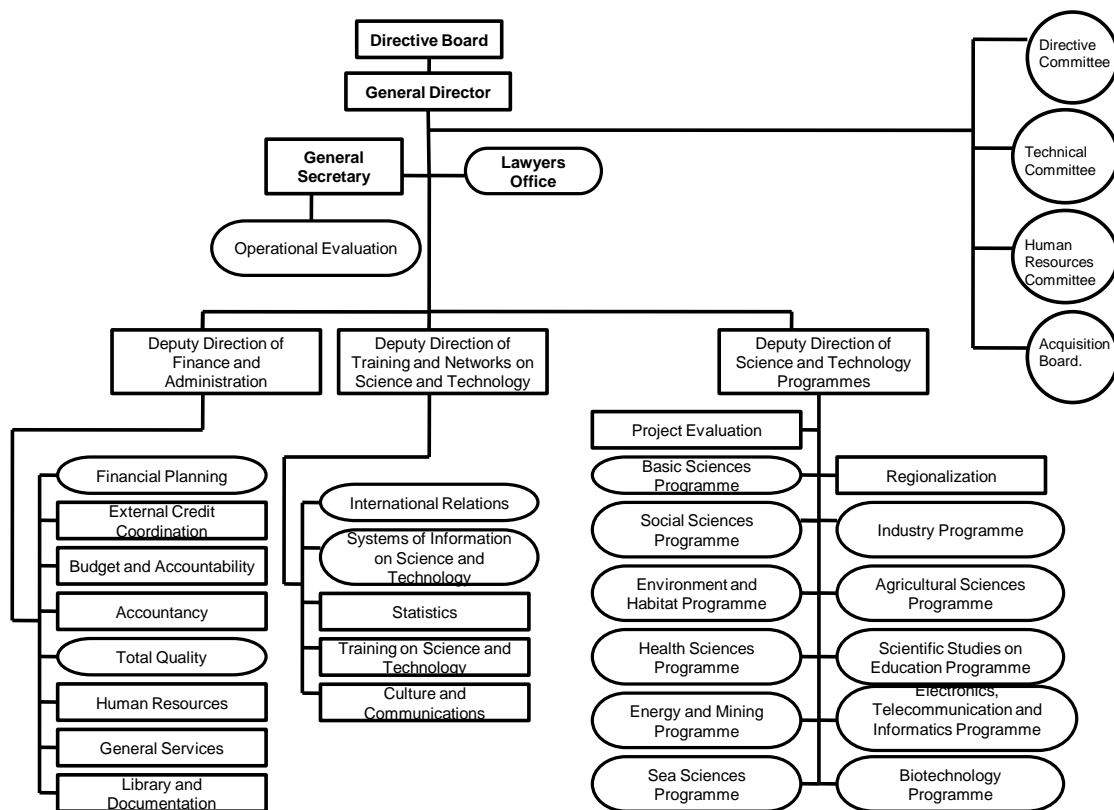
As part of the consensus building process, Colciencias conducted a series of seminars across the country with several objectives: i) to present the Colciencias policy proposal; ii) to discuss institutional arrangements; iii) to set up “rules of the game”; and iv) to listen to the ideas and proposals of stakeholders regarding the future of S&T in Colombia. The results of this participatory process were summarized in two documents: “*Ciencia y Tecnología para una Sociedad Abierta*” (Science and technology for an open society) (Colciencias, 1991), and “*Convocatoria a la creatividad*” (Call for creativity) (Colciencias, 1992). Some of the key ideas that guide the SNCyT were expressed by President Gaviria in the prologue of one of the books mentioned above, where he proposes a “system based on communication, interdependence, and building or creating strong ties of exchange and association (i.e. networks) between various actors, and not on the establishment of bureaucratic agencies” (Colciencias, 1991, p. V).

Colciencias is an organization that follows the SNCyT structure (see figure below). That means that it has a unit for each National S&T Programme, and a unit that coordinates all the regional commissions, as well as other cross-cutting programs such as scholarships for PhD training, S&T communication and diffusion, and internationalization of S&T communities.

One event that favoured the implementation of the SNCyT was the increase in the Colciencias budget, due mainly to the second IADB credit program for S&T, launched in late 1991⁶⁹. The program aimed to support both research and innovation activities and doctoral training, among other activities.

⁶⁹ The amount of the credit was US\$66.7 million. The objectives of the credit differ a bit from the former credit, including the promotion of innovation projects in the productive sector and scholarships for doctoral studies. The other components were oriented to support R&D projects and capacity building. This was the only foreign credit, of the ones given to Colciencias, that determined that private companies who were given a credit for innovation activities had to pay back, helping the Colombian government to recover part of its expenditures. The credit instrument as such changed afterwards; now Colciencias gives a subsidy to pre-pay the credit which is granted by a public investment bank.

Figure 11: Colciencias organizational chart 1990s

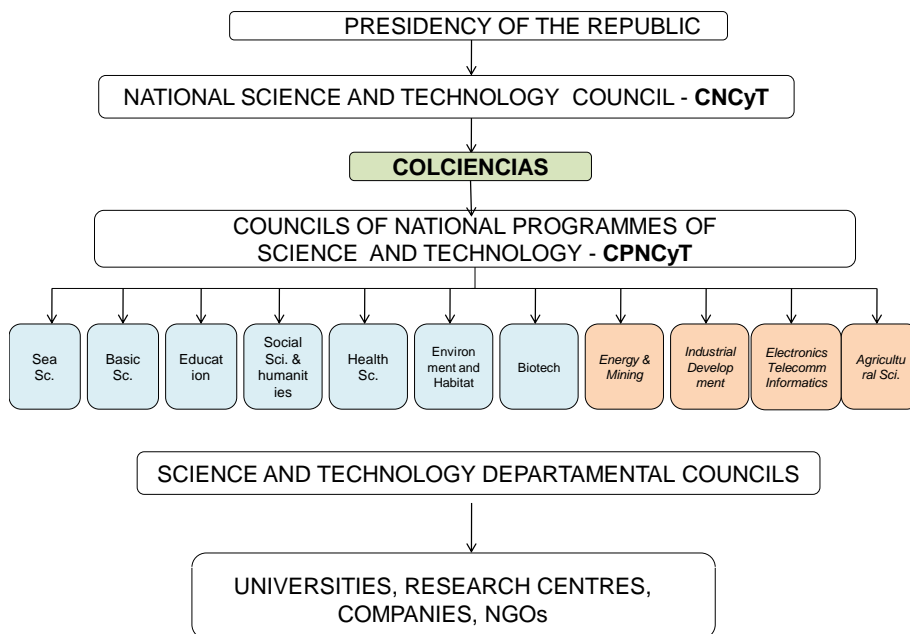


Source: Colciencias, 1998.

In 1995, the National System of Innovation (NSI) was ‘formally’ created, as part of the SNCyT, and new policy instruments were set up to attend to private sector needs. The creation of the NSI was framed by the national STI policy of the moment (República de Colombia & Departamento Nacional de Planeación, 1994) and the national development plan. In Colombia, the concept of system of innovation has been used to guide policies and as a policy instrument. The NSI was conceived as a creative space for social learning, for the generation and exchange of information and knowledge between different agents at the national and regional levels, looking to increase the productivity and competitiveness of the productive sectors, to generate employment and to improve the quality of life (Consejo Nacional de Ciencia y Tecnología, 1995). Because of the creation of the NSI, the organizational arrangement of Colciencias changed. The S&T programmes were divided into two groups: those oriented primarily towards

scientific research (basic sciences, social sciences, education, sea sciences, health, environment, and biotechnology⁷⁰) and those oriented mainly towards innovation (industry, agriculture, energy and mining, and electronics, telecommunications and informatics). See below a common representation of the Colombian SNCyT, differentiating between innovation oriented programmes (in pink and italics), and scientific programmes.

Figure 12: Representation of the Colombian SNCyT in the 2000s



Source: Colciencias, 2008.

In fact, the science and technology system and the innovation system are intertwined, not independent, although people for many years talked about them as two separate systems. They share the same head, that is Colciencias; they share financial resources, Colciencias' budget, (although the strategies are differentiated within the budget); and the structure of the programmatic councils remained the same, as did their manner of operation. There are actors operating within both systems, but there are also specific actors for each one. The

⁷⁰ Many analysts will question why biotechnology was not included then in the innovation oriented programmes; it was because of personal relations and not a rational policy decision. In 2010 the biotechnology programme was moved from the Research Programmes Direction to the Innovation Direction, inside Colciencias.

differentiation is made mainly for the purpose of analysis. In real life, innovation activities differ from research activities, having different problems, objectives, logics, policy instruments, and incentives. In any case, the major difference between both concepts is the entity that plays the main role, the centre of the NSI is companies and that of the SNCyT are universities and R&D centres. In the developed world, the expression "innovation system" is more commonly used, since enterprises are the main users of knowledge⁷¹ - and sometimes producers- and funders of scientific, technological and innovative activities. In developing countries, such as Colombia, R&D universities and institutes continue to be the main actors and are the producers of knowledge *par excellence*, so the use of the term "S&T system" may be more appropriate.

Since the conception and creation of the SNCyT, innovation has played a major role along with science and technology, together conceived as a means of productive transformation. The creation of the NSI was Colciencias' response to the requirement of the productive sectors for a more defined "space" for their demands and needs. The intention, however, was not to fragment the SNCyT. In principle, and according to the legal framework, there is only one system with some specificity about the actors, the institutions, and policy instruments. The conformation of the NSI promoted the creation of various innovation support organizations, such as technological development centres, spin-offs incubators, tech parks, and risk capital agencies. This is a clear example of how in developing countries it is believed that the NSI can be 'created', instead of the 'spontaneous' emergence of organizations, alliances and interactions when needed. In addition to these new organizations, governmental agencies, as well as commercial banks, not previously articulated with Colciencias, started to play an important role in the promotion of innovation, such as IFI⁷², Bancoldex⁷³, FNG⁷⁴, Proexport⁷⁵, and SENA. SENA is the public agency in charge of technical

⁷¹ The Triple Helix model followers argue that universities are gaining again a major role in the advance of STI in developed countries.

⁷² The industrial promotion fund.

⁷³ The national import-export bank.

⁷⁴ The national fund for guarantees.

⁷⁵ The national agency for exports promotion.

training, which has become a central player in the Colombian innovation system, not because of its role but because of its money, as it will be explained later.

In 1995, the Science, Technology and Development Mission, launched in 1993, published a document titled “*Colombia: Al Filo de la Oportunidad*” (Colombia: On the Edge of Opportunity) (Presidencia de la República & Colciencias, 1996), which can be described as the first long-term S&T plan, attempting to provide a navigational chart for the course of science, education and development. The proposal was articulated around three axes: organizational changes; education; and science, technology and society. The Mission recommendations have remained in the national “imaginary” because the goals proposed have not been achieved. For instance, it proposed that by 2007 the country should be investing 1% of its GDP in scientific and technological activities (in 2008 the national expenditures in STI activities were 0.4% of GDP); and the PhD training of 800 persons annually for 10 years (on average, during the 2000-2008 period, Colciencias provided support to 112 people and combining all agencies that grant scholarships the number of beneficiaries rises to 202). (See section 3.6 for more data).

In 1996, during the execution of the third IADB-Colciencias credit programme⁷⁶, Colciencias budget reached its peak (surpassed only in 2009). Contrary to the belief that foreign credit has been used by Colciencias to oblige the central government (i.e. DNP and the Ministry of Public Finances) to provide matching credit funds, at this moment it did not work out, due to a non-supportive government that gave a low priority to S&T. The programme was supposed to be implemented in three to four years, but budget cuts which started in 1998 extended its execution to 2002.

Because of the small budget for S&T and its volatility, which depends on central government allocations, the DNP promoted Law 344/1996, which aimed, first of all, to direct SENA’s activities towards technological development, and

⁷⁶ The amount of the credit was US\$219 million. The main objectives of the programme were similar to the second, increasing support for the components of innovation promotion and doctoral training.

secondly, to divert part of SENA's financial resources to Colciencias. SENA is funded by a percentage of all company payrolls. Because SENA has a large "secure" budget, with more than a hundred of sites across the country, it has a strong political lobbying capacity in Congress, which makes the institution almost "untouchable". As a result of this bill, the composition of all decision-making bodies of the SNCyT was modified to include a SENA representative, as part of the government sphere. Unfortunately, the law was not complied with and SENA did not allocate funds to Colciencias. Another law was needed for making this happen (Law 812/2003). Law 344 states that 25% of SENA's funding shall be dedicated to innovation, technological development and competitiveness, and law 812 stipulates that 20% of this 25% shall be transferred to Colciencias. This mandate has generated a difficult relationship between the two agencies, and every year negotiations are needed to define how SENA's money is going to be invested by Colciencias.

In 1999, Colciencias promoted the creation of the Colombian Observatory of Science and Technology (OCyT by its acronym in Spanish). From the beginning, the OCyT was conceived as a public-private partnership; 25 organizations joined Colciencias in establishing the Observatory, including universities, other public institutions (the National Department of Planning and a regional government), R&D centres, scientific associations, and producers associations, among others. OCyT associates, different from Colciencias, have contributed to creating a counterbalance to Colciencias' intention to control the Observatory, since it provides around 80% of the core funding.

Two situations were determinant for the creation of a science and technology observatory in Colombia. The first was the need for indicators to support the design and evaluation of S&T policies⁷⁷. The second one was the founding of the Ibero-American Network of S&T Indicators (Spanish acronym, RICYT), which promoted the creation of endogenous capacities in Latin American countries. Complementary to these situations, two seminars were held

⁷⁷ The OCyT publishes annually the book "S&T indicators – Colombia", which can be downloaded from <http://www.ocyt.org.co>

in Colombia to evaluate the state of the art regarding S&T indicators. In November 1995, Colciencias and DNP organized a meeting to present international experiences, including those of France, Brazil, Mexico, the OECD, and the European Union. These discussions provided the guidelines for the creation of the Colombian Observatory. The proceedings of this meeting were published under the title *“Hacia la Construcción de un Observatorio de Ciencia y Tecnología”* (Towards the construction of an observatory of science and technology” (Colciencias, 1996). Subsequently, in April 1996, Colciencias and RICYT organized the second Latin American Workshop on S&T indicators. The papers, conclusions and recommendations were published in *“El Universo de la Medición – La Perspectiva de la Ciencia y la Tecnología* (The universe of measuring – Science and technology perspective) (Jaramillo & Albornoz, 1997).

Let me discuss the S&T policy-making process. Briefly, national STI policy is formulated by Colciencias and then ratified by the CNCyT; sometimes converted into a CONPES⁷⁸ document⁷⁹. Some analysts argue that only the policies that become CONPES documents have been taken into account or had some impact. However, there are no big changes or differences between policies formulated by different administrations; therefore, it is difficult to say if some of them have been more influential than others. The translation of this policy into specific recommendations for particular sectors and scientific fields is in the hands of the programmatic councils. Colciencias, as the head of the system, enforces the policies with a great deal of success due to the prior debate process which legitimizes the policies. The legitimization process consists of accepting the policies and rules of the game formulated by Colciencias, building collective arrangements, and achieving social consensus, especially on how decisions are made (Villaveces & Forero, 2007).

⁷⁸ The CONPES (National Council of Economic and Social Policy) is headed by the President, the Secretariat is held by the DNP, and all Cabinet Ministries participate. It is considered a central policy forum and decision-taking instance within the Colombian State. However, CONPES documents are not binding.

⁷⁹ See for instance, CONPES 2739/1994, national S&T policy 1994-1998; CONPES 3080/2000, national STI policy 2000-2002; and CONPES 3582/2009, current national STI policy. These documents can be downloaded from www.dnp.gov.co.

Another feature of national S&T policies is that they have been quite stable over the years, with cumulative effects (Jaramillo, et al., 2004; Villaveces & Forero, 2007) despite changes in the government. Why is that? Several factors could be mentioned, including: i) a quite stable and technical bureaucracy (i.e. Colciencias managers); ii) the IADB loans, whose objectives have not changed much over the years; and iii) a learning organization, which has maintained most of the successful S&T promotion programmes. The IADB has been an important source of funding, and is influential in the orientation of policies and design of policy instruments. With regard to Colciencias personnel, there has been very little turnover of low and medium level officers over the years, guaranteeing certain stability. There are different types of high-level officials - deputy directors and the managers of national programmes of S&T, some of whom are civil servants (also very stable) and others are university professors and researchers who are on commission in Colciencias. From a governance point of view and a principal-agent relationship, this creates a special situation, where the influence of the scientific community is certainly greater in Colciencias –and the SNCyT- than in other S&T agencies.

Although during this period (1989-2000) Colciencias became more visible within the Colombian state, however it was not attractive to politicians due to its small budget and personnel, which is why it has remained marginal. The ups and downs of this period, especially those regarding public funding, did not contribute to the consolidation of the SNCyT.

3.4 2001-2008: Articulation and information are the key

The SNCyT has evolved throughout the years; some changes have been introduced from within the System and others have been exogenous. This period is characterized by a deepening of the articulation of the three groups of actors. The principal recommendations formulated in the national STI policy for the period 2000-2002 were oriented to articulation issues mainly between government agencies (República de Colombia & Departamento Nacional de

Planeación, 2000), looking for ways to strengthen the interactions and relationships between Colciencias, the ministries, SENA and other organizations. For instance, with regard to government agencies, several ministries and other public organizations⁸⁰ have transferred financial resources to Colciencias in order to make special and strategic calls for proposals of interest to these actors. For example, law 643 of 2001, which created the Health Research Fund with resources from lotteries, is a unique case because it is a stable and permanent source of funding; Colciencias directly receives and administers the money, and launches specific calls for this S&T field, separate from the rest of the S&T programmes. Because of this, the Ministry of Health has asked for more seats in the programmatic council, and intervenes in the orientation of the programme and the approval of projects. The SENA exerts similar influence to that of the Ministry of Health, which each year enters into long and stressful negotiations with Colciencias to determine how SENA's money is going to be invested.

In 2002 a new international loan was granted to the Colombian government, this time through the World Bank, and directed towards higher education, with two public institutions as beneficiaries: ICETEX and Colciencias. In the case of Colciencias, the money was aimed at promoting national PhD programmes, providing funds for infrastructure and lab equipment, and scholarships for PhD students.

The articulation of the actors can also be observed through two factors: information systems and adoption of policies not associated to financial incentives. At the turn of the twenty-first century, Colciencias launched two major information systems known as Publindex and ScienTI. The first one is the index of Colombian scientific journals, which has two main objectives. On one hand, it established quality standards for journals, thereby qualifying the work of journal editors. On the other, it provided the ranking of national and foreign journals, which is used by universities to assign incentives for publications by professors. The ScienTI platform has several components, such as CvLAC (curriculum vitae

⁸⁰ It is important to remember that during this phase a percentage of the SENA budget was finally being transferred annually to Colciencias, in accordance with Law 812/2003.

database), GrupLAC (research group database), and InstituLAC (institutions database). The CvLAC contains 170,000 records of people involved in S&T activities, although not all can be considered researchers. By the end of 2008 there were nine thousand entries in GrupLAC, of which Colciencias classified 3,727 groups according to the level of education and training of the members and their results (publications, patents, etc.)⁸¹. GrupLAC and CvLAC are clear cases of adoption of Colciencias instruments that do not offer direct financial incentives to the users.

Research groups are considered by Colciencias to be the basic units that host researchers, doctoral and master students, and young researchers (graduate students with an interest in beginning a career in investigation), organizing themselves around research lines and projects. Since 2002 Colciencias has classified the groups on the basis of their scientific and technical productivity, the number of members and their level of education, among other variables (Consejo Nacional de Ciencia y Tecnología & Colciencias, 2008)⁸². The ranking today includes A1 (top), A, B, C, and D groups. The classification methodology has changed over the years, and at some point there were more A groups than D, which is an inverted pyramid, a situation that raised questions about the ranking system (Colciencias, 2008)⁸³. Nevertheless, the research community responds to Colciencias calls for registering the groups, with no other incentive than the possibility of receiving funding.

Generally speaking, Colciencias has been quite successful in implementing policies. Analysts and Colciencias officials think that is due to broad-based consultation processes, in the formulation and negotiations phases. I think it is because of the organization of the SNCyT, which facilitates the flux of information; in this way, the adoption and implementation of policies is facilitated.

⁸¹ The rest of the groups are registered but not recognized by Colciencias, because they do not fulfill the minimum requirements.

⁸² See Colciencias web page for an explanation of the ranking model, as well as the document just referenced.

⁸³ Part of the problem was that the ranking model has a fixed threshold, so as groups increased their capabilities and results, they ascend in the scale, resulting in having more top A groups rather than C and D groups.

The interviews and surveys undertaken for this thesis will allow me to prove or disprove these assumptions.

It is important to emphasize that the functions of S&T policy-making and funding in Colombia have been made under a sole government agency, that is, Colciencias. In the early years, Colciencias was primarily a granting agency. In the 1990s, with the enactment of Law 29, a clearer policy-making role was given to Colciencias, one more reason to put the agency closer to DNP. In 2006 Colciencias was admitted to the CONPES sessions, as a guest; then, the invitation to Colciencias was seen as a major recognition to the importance of STI for economic and social planning and development: Just until 2009, with the enactment of law 1286, Colciencias participation in CONPES was with “all the rights”⁸⁴.

Despite the institutional changes that occurred during the previous period, many argue that Colciencias was still facing many problems and constraints, which have repercussions on the SNCyT. More importantly, within the state apparatus Colciencias had not achieved enough leverage to enforce STI policy, had no legal authority to propose laws, and did not manage its own budget (it depended on the planning sector’s budget). Academics contend that the functions of policy-making and funding should not be under the domain of same agency” (see for instance Hart, 2001; Teubal, 2002). Colciencias’ officials, former and current, do not agree that these functions should be combined. From my perspective, I don’t think that at the present the agency and the SNCyT benefit from that, on the contrary I think it is a disadvantage and it is putting a lot of constraints on national STI development, mainly because Colciencias has limited resources (human and financial) for functioning, and the demands of the communities are increasing rapidly, thus Colciencias’ response is not adequate. Similarly, the World Bank says:

The main STI agency, Colciencias, who is responsible for the implementation of the programs for the development of scientific and

⁸⁴ In the words of Juan Francisco Miranda, Colciencias General Director 2007-2010, having all the rights means: “with a chair at the main table, not sitting at the side”.

technological capacities, depends administratively on the Department of National Planning. However, as executing agency, Colciencias seems to be out of the circle of governmental agencies in charge of planning and coordination. In consequence, Colciencias does not have an independent budget and has little direct influence on budgetary negotiations. This can contribute to fluctuations on public funding for STI, since annual budget negotiations could omit long term financing needs and priorities, such as STI (World Bank, 2007, pp. 196-197).

Monroy⁸⁵ attempts to study the interactions between agents of the SNCTI, but does not get any deep in typifying those relationships, apart from establishing with whom each agent primarily relates, and the formality or informality of those interactions. From the results obtained, she states that “actors perceive that the system does not function but they do not have the capacity to formulate any proposal to improve it” (Monroy, 2004, p. 82). Similarly to Monroy, other analysts (academics and practitioners) usually manifest that the lack of articulation is one of the problems of the Colombian SNCyT, but they fail to characterize the disarticulation; is like a common ground where all fall, but no one describes (see for instance Colciencias, 2008; Malaver & Vargas, 2005).

By the end of this period the STI communities and the country in general, perceive that Colciencias and the SNCyT have grown and gotten stronger, but changes need to be done. In 2005 the Maloka forum was set up with the objective of discussing a new S&T law. For over two years many people participated in the debates. In 2007, the law project was taken over by two congress people⁸⁶ as “their own”, who promoted the bill in the Senate and the Low Camera. In the next section the law will be presented.

⁸⁵ Monroy studied the articulation of the SNCTI, based on inquiries to institutional actors, representing different “subsystems”: i) the scientific/academic (e.g. R&D centres, universities); ii) productive (e.g. firms, producer associations); iii) the technological (e.g. incubators, tech development centres); iv) the financial (e.g. commercial banks, capital risk agencies); and the enabler (e.g. DNP, Colciencias, Ministries, SENA, and OCyT). She conducted a survey to a representative sample of the first three subsystems, and interviews were conducted to people representing the latter two sectors.

⁸⁶ It is interesting to note that these first-time congresspersons, who unquestionably promoted STI issues, were not re-elected. Similarly, another senator in the early 2000s, who also advocated for STI development, lasted only one period in the Congress. It seems that S&T has no votes, no political cost, and no visibility, as one of the interviewees says (I-D): it has no mourners as other interviewee states (I-I).

As time passes and Colciencias acquires more visibility, it has lost autonomy and becomes more bureaucratic. Colciencias is certainly not a typical government agency, although it is now more linked to other public offices and the executive branch is participating in science and technology decisions. Because of its participation in the decision-making process and its increased importance in politics, the organization has become more bureaucratic and subject to political influences. However, I believe it is better to be less autonomous and to have the chance to participate in the decision-taking processes, so that STI is in the public agenda and STI policies become part of economic and social national strategies and priorities.

3.5 The present time

After four years of debate and several attempts to knock down⁸⁷, a new science, technology and innovation bill, law 1286, was enacted in February 2009. The law makes some changes to the SNCyT and Colciencias. Firstly, the system clearly incorporates the word *innovation*; therefore, we now formally make reference to the National System of Science, Technology and Innovation (Spanish acronym SNCTI⁸⁸). The systems as such did not change, the compositions of the collegiate corps and their functions remained basically the same, exception made of the national council. Second, Colciencias was transformed into an Administrative Department (like the DNP), which makes it a technical entity that responds directly to the President of the Republic. Besides becoming an Administrative Department, Colciencias acquires the right to sit permanently at CONPES sessions, and the Cabinet Ministers Council. In addition, it created the National Fund for Research and Innovation “Francisco José de Caldas”, which facilitates the administration of public and private funds,

⁸⁷ SENA tried to modify the law to its benefit, arguing that the innovation system was not part of the SNCyT and that SENA, and not Colciencias, should be the head of the NSI.

⁸⁸ As said before since 2006 the incorporation of the word *innovation* and the use of the acronym were already in place, but it just until the law was enacted that the SNCyT officially changed its title.

but does not have permanent and stable resources, depending on annual allocations.

The CNCyT was transformed into an advisory council for STI, even if it has a large number of government officials (four ministers and DNP General Director), the number of researchers and productive sector representatives increased from one to four. It is too early to tell if this new composition is producing changes, but they are meeting more frequently to discuss policy issues; once a month compared to every three or four months in the past. The functions of the council also changed, especially those regarding administrative or bureaucratic functions; for instance the approval of tax incentives was suppressed.

By the end of the latter period, a set of policy documents were prepared with similar overarching objectives, strategies and guidelines. The first is a long term plan called *Vision 2019 II Centenario*, in preparation for the commemoration of the independence bicentenary, coordinated by DNP. The scientific and technological development and innovation plan 2007-2019, part of *Vision 2019 II Centenario*, was drafted by Colciencias and DNP. In 2007, as part of the national development and investment plan “*Estado Comunitario: Desarrollo para todos 2006-2010*” (Communitarian state: development for all), a special chapter on science, technology and innovation was included as one of the special development dimensions. In 2008, Colciencias launched the national research and innovation policy “*Colombia Siembra y Construye Futuro*” (Colombia sows and builds for the future) (Colciencias, 2008), after a broad-based consultation process and with the approval of the CNCyT. Lastly, a CONPES document was issued in 2009, with the participation of various government agencies, such as DNP, SENA, ICETEX, and the ministries of Industry, Agriculture, Defence, Education, Finance, Social Protection, Environment, and Energy and Mining.

As mentioned above, Colombia has depended on foreign credits for STI promotion, which have been important because they compel the Colombian government and S&T institutions to finance research and innovation activities to

allocate more financial resources. Because of the lack of sufficient funding, the current Colciencias administration has been negotiating with the World Bank and the IADB for a new loan of up to US\$500 million, to be executed from 2011 onwards. These credits granted to Colciencias are taken by the Colombian government, which is the one in charge of paying them back.

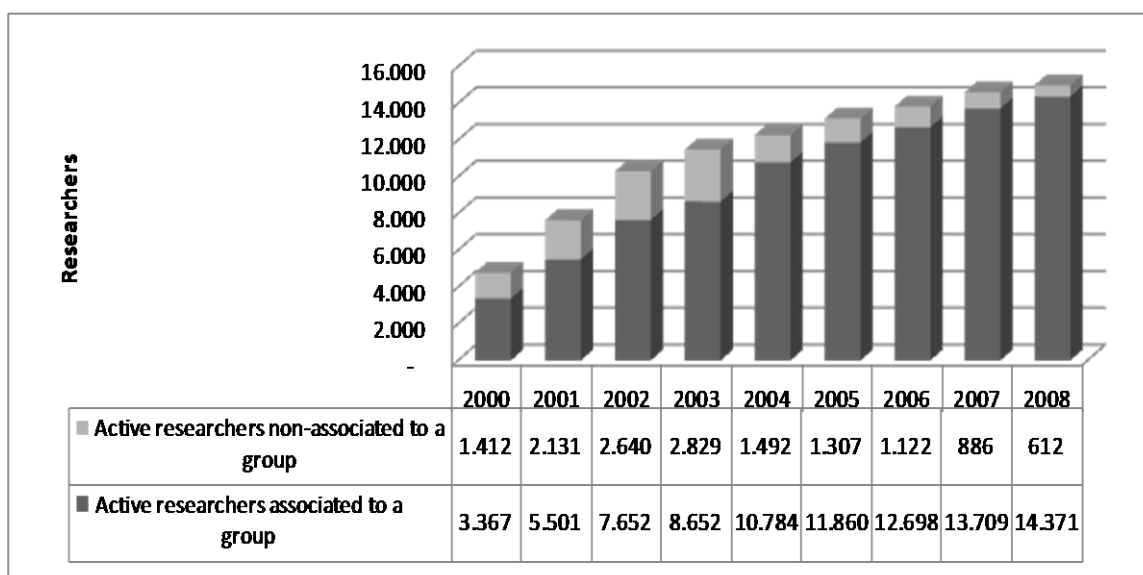
3.6 The Colombian Science, Technology and Innovation System in figures

To put the above into context, it is important to present some S&T indicators that provide another picture of the Colombian SNCTI: Colciencias budget, Gross Expenditure in R&D and S&T activities as a percentage of GDP, scientific publications, and number of research groups and researchers. Most of the data is available for the period 2000-2008; in a few cases, prior years will be presented. As we have indicators that show the “fragility” of the SNCTI with respect to the amount and instability of government funding, we also have other indicators that show the strength of the SNCTI, based on the response of the research community, observing the steady and sharp increase of research groups, researchers and scientific publications, despite the lack of sufficient public resources. Unfortunately, there is no information about firms that allows us to do similar analyses, studying their innovative performance and attitudes, and in particular, their response to public support for innovation. Although in Colombia we have conducted three innovation surveys, in 1996, 2005 and 2007, the data is not comparable, and results from the latter are not yet available.

The Colombian system is rather small compared to other Latin American countries of similar size and degree of development, by any measure: expenditures, researchers, PhDs, or publications. First, the scientific community in Colombia is very small, even if it has tripled over the last decade. Colombia has approximately fifteen thousand active researchers, which means 333 researchers per million inhabitants or less than one researcher (0.75) per

thousand people in the labour force⁸⁹. Active researchers are those who have registered their curriculum vitae in CvLAC, the database managed by Colciencias, and have produced scientific or technological material (e.g. articles, patents, books, etc.) in the past two years. Investigators can be associated with a research group, following the Colciencias policy to institutionalize scientific activity, or work independently; data shows that most of them are associated to a research group (96% in 2008). Of those researchers, only 4,871 have a PhD degree, which means less than a third of all active researchers. Based on data published in RICYT webpage, Colombia has 11 PhDs per 100,000 inhabitants; in comparison, Argentina has 39, and Brazil 23.

Table 5: Active researchers, 2000-2008



Source: OCyT, 2009a& 2009b; original data Colciencias GrupLAC and CvLAC.

With regard to financial constraints, it is well-known that most developing countries have low budgets for scientific, technological and innovation activities⁹⁰ in general, and even lower for research and development. Colombia is not an exception, but it is worse than many Latin American countries. Colombia

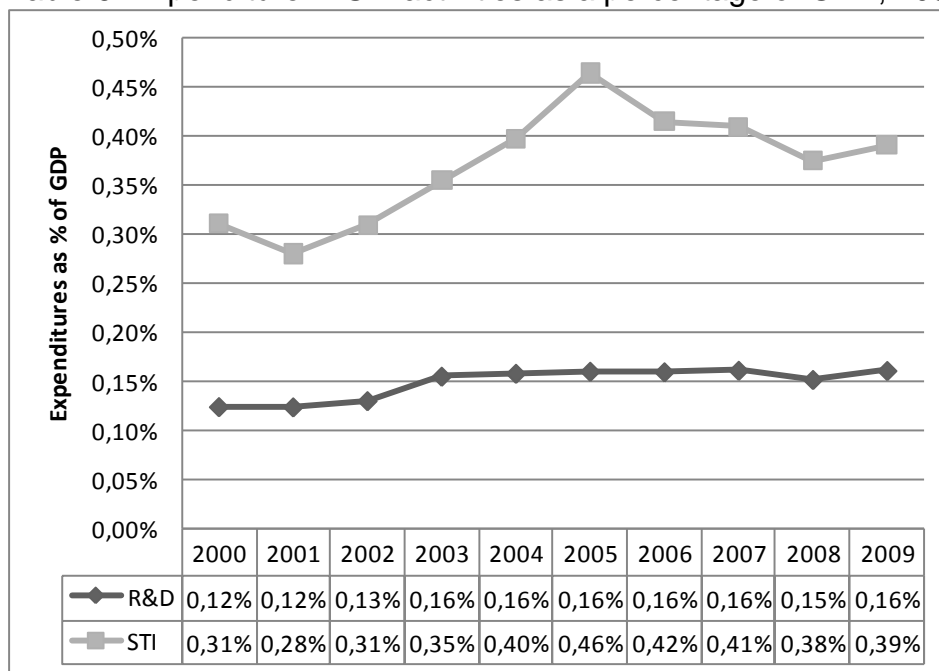
⁸⁹ Canada has 7 researchers per thousand of the labour force, Argentina 2.8 and Brazil 1.4 (see RICYT webpage for international comparisons, www.ricyt.org).

⁹⁰ Expenditures in STI activities include: R&D, scientific and technical education and training, S&T services, administration of S&T activities, and industrial innovation; they could be referred as S&T or STI activities.

expends around 0.4% of its GDP in STI activities (see table 6), while Brazil spends approximately 1.5%, Argentina 0.6% and Costa Rica 1.3% (these are 2007 figures, taken from RICYT web page). Colombia has been improving but is still lagging behind. In table 6, we can observe that expenditures for R&D are stable, remaining at 0.15% of GDP.

Several analysts of the S&T situation in Colombia observe a kind of contradiction between the results and the money invested in this area. For instance, Jaramillo says: “S&T policy in Colombia has not had a correspondence between the institutionalization, the accumulation of policies, and the set up of instruments, with the financial resources assigned” (Jaramillo, 2007, p. 315). The country has learned over the years to formulate research and innovation policies, and create interesting and innovative policy instruments, but these have not been supported by adequate amounts of public investment. With little money a lot has been done, and at least, research communities have adopted the policies and responded to those incentives, and have grown. But the sustained growth of the communities depends principally on having proper funding, that is certainly the “black dot” of the evolution of the Colombian SNCyT.

Table 6: Expenditure in STI activities as a percentage of GDP, 2000-2009

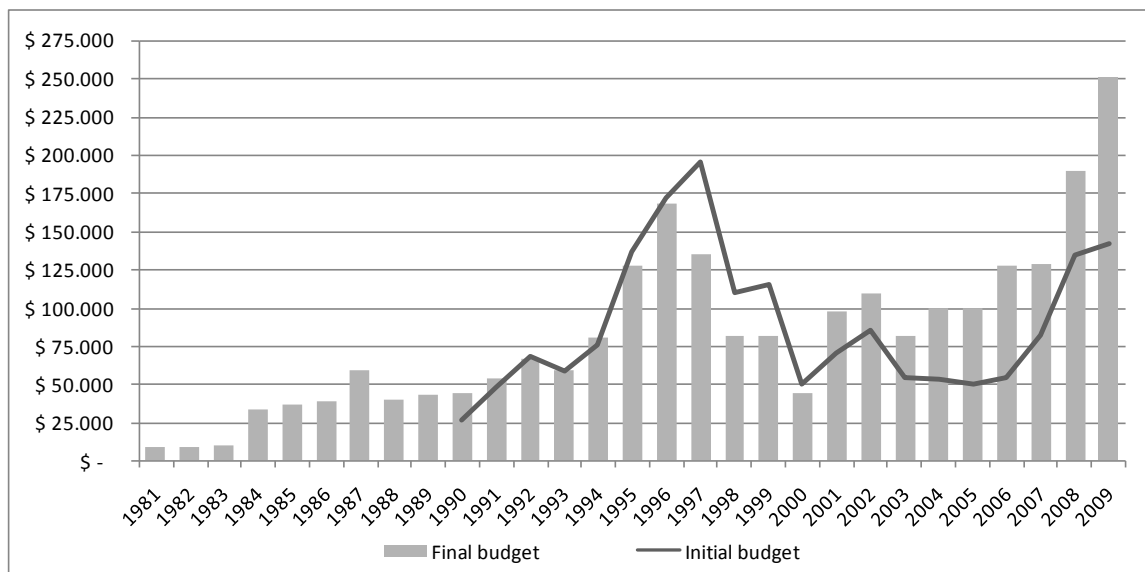


Source: OCyT, 2009a & 2009b.

Just by looking at Colciencias' budget we can tell that the fluctuations are remarkable (see figure 13⁹¹). The first substantial increase was in 1983 when the first IADB credit was acquired; this money lasted until 1987. Between the first and second credits, we can observe a small decrease in funding. The Colciencias budget peaked in 1996 when it was implementing the third program with IADB. Subsequently it suffered a major decline due to a non-supportive government - President Pastrana's administration (1998-2002) – which gave a very low priority to S&T, and the budget cuts almost resulted in the disappearance of Colciencias. The period 2000-2008 was not very stable, but a permanent increase can be observed after 2005. Because of the fluctuations, it has not been possible to ensure a sustained investment effort due to unstable funding; therefore, long term goals have not been fulfilled, such as those formulated by the Science, Technology and Development Mission.

Figure 13: Colciencias investment budget 1981-2009

(Millions of Colombian 2007 constant pesos)



Notes: 2009 is estimated. Initial budget is the original allocation by the central government, and the final budget is after additions (mainly SENA) and cut backs.
Source: Colciencias.

⁹¹ As in most Colombian public agencies, they are assigned an initial budget when the central budget is defined by the central government; and later during the execution, additions and cuts are made. In the case of Colciencias, most of the increase every year is due to the transference of SENA's moneys.

The distribution of Colciencias budget between STI strategies also reflect the importance of the funding of research and innovation projects inside Colciencias that is channelled through the programmatic councils. In the period 2001-2008 project funding was assigned 71% of Colciencias' funds, 27% went to scholarships, and the rest was distributed between various activities and strategies including regionalization of STI, international relations, appropriations of S&T, etc. (Colciencias, 2008; OCyT, 2009a, 2009b).

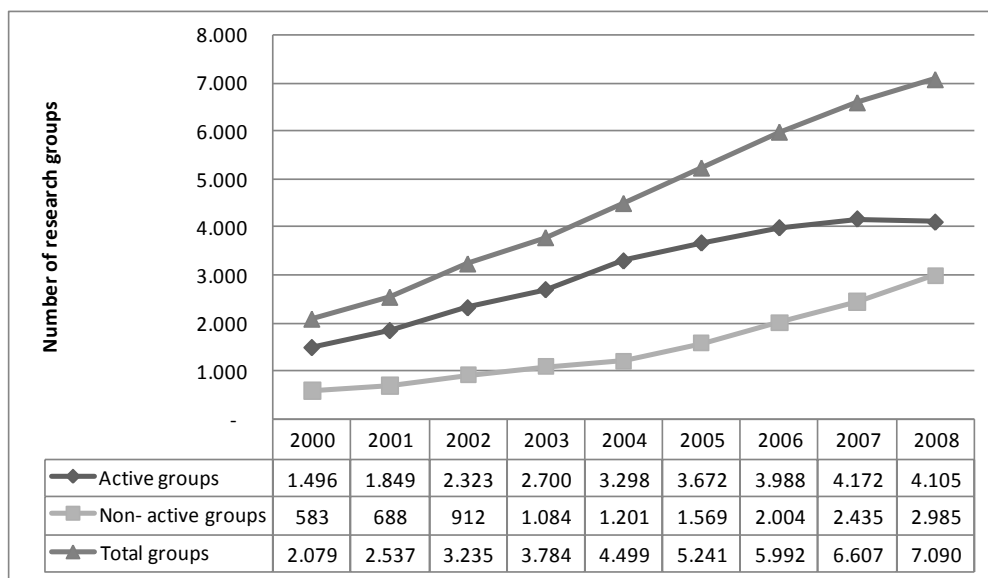
Despite the existing organizational and financial problems, many experts argue that Colombian S&T policy has been quite successful, and that is also what the indicators manifest. The strengths of the SNCyT are observed in the increase of research groups, researchers, and scientific production published in national journals and in journals indexed in the Web of Science or Scopus (Colciencias, 2008; Jaramillo, 2007; Villaveces & Forero, 2007).

As mentioned above, the unit of analysis or “policy subject” defined by Colciencias is the research group, therefore its evolution illustrates the improvement of research capacities in the country. The Colombian Observatory of Science and Technology has used a methodology that is different from the Colciencias classification (presented in section 3.4 above) for the purpose of producing indicators. Rather than qualifying the quality of the groups, it determines which groups are active, based on their regular scientific and technical production⁹². Certainly, the growth of research groups is interesting; from 2000 to 2008, the number of active research groups has almost tripled, while non-active groups have grown fivefold; universities host over 90% of them, and the rest are distributed between (private) research centres, government agencies, NGOs, and corporations. The use of the database and ranking system is another example of the acceptance by the actors of the SNCyT of policies

⁹² See Colciencias web page for full information on the production that research groups can registered and how the agency qualifies it for the ranking process.

implemented by Colciencias⁹³. Moreover, the universities and the R&D centres employ it to increase groups' visibility (Colciencias, 2008).

Table 7: Research groups 2000-2008



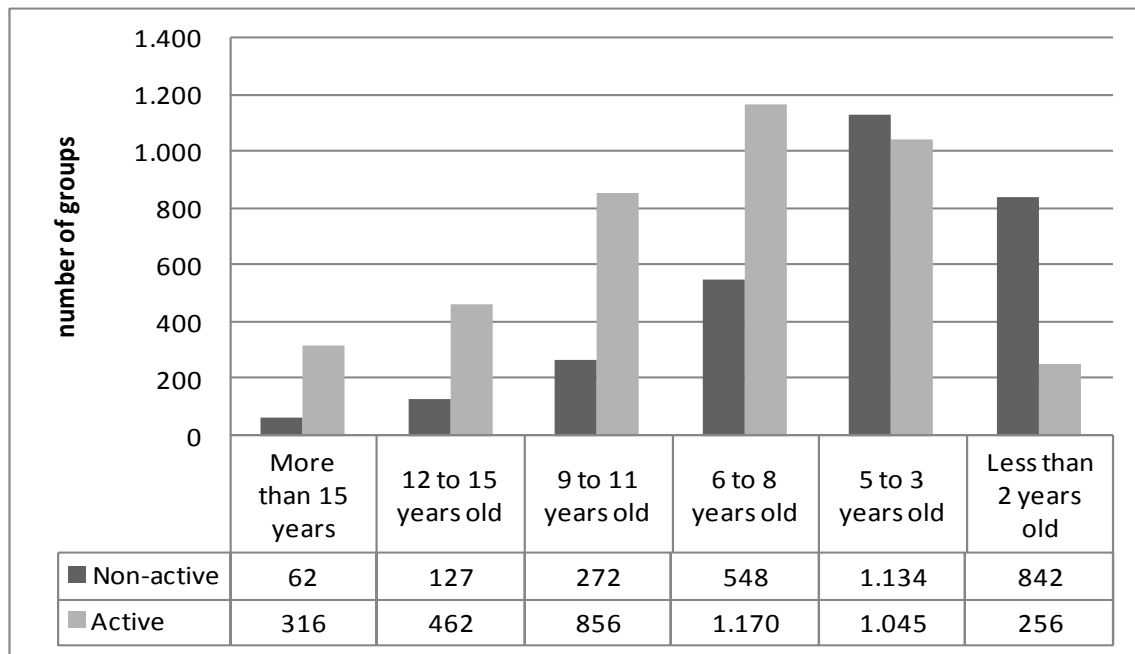
Source: OCyT, 2009a & 2009b; original data Colciencias-GrupLAC.

The table above shows a steady increase in the total number of research groups in Colombia, which can be attributed primarily to new and non-active groups⁹⁴. Analyzing data presented by OCyT (2009), most of the active groups are over six years old (2804), while most of the non-active groups are under six years old (1976) (see table below).

⁹³ Because of the importance of the group ranking, Colciencias consults the research community before making any changes. In fact, the most recent change of the methodology was made under the guidance of an external committee.

⁹⁴ Non-active groups are those that did not register any production in the two years prior to the Colciencias ranking call.

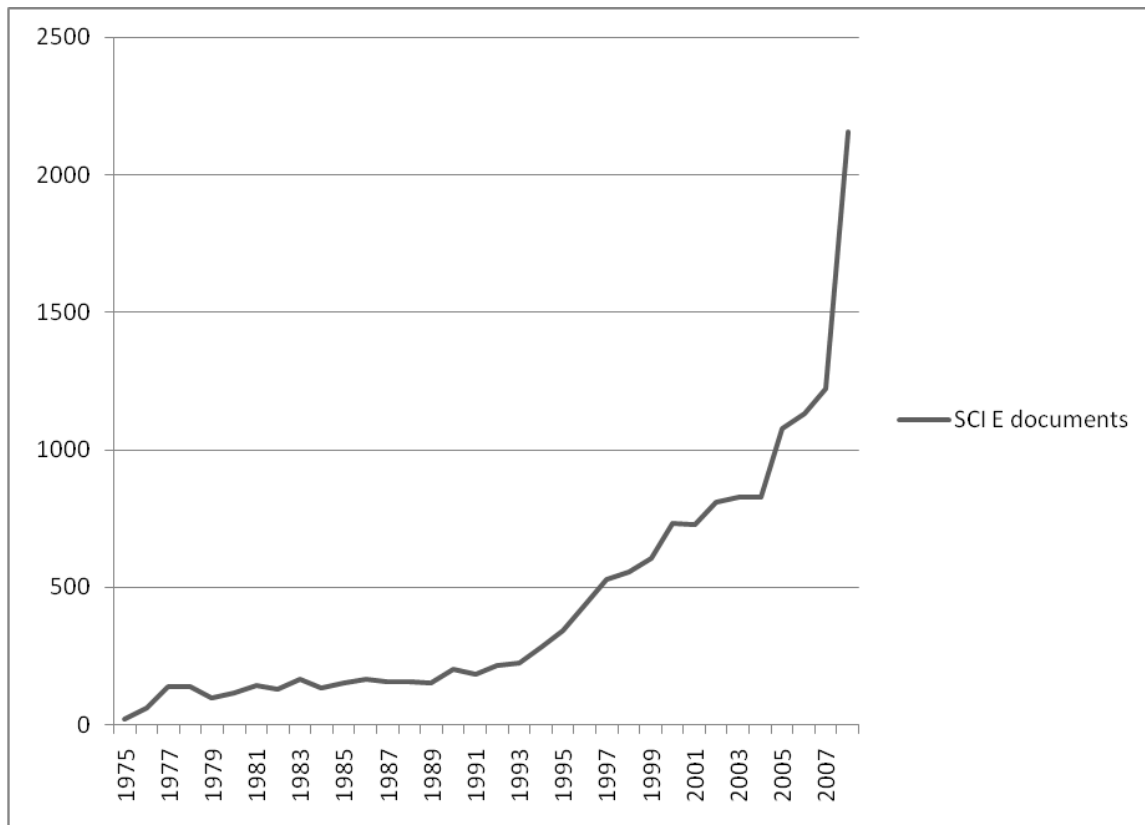
Table 8: Research groups by seniority, 2008



Source: OCyT, 2009; original data Colciencias GrupLAC.

Regarding scientific production, it can be argued that the permanent growth of scientific publications correspond to the accumulation of research capacities or building of intellectual capital at the different levels: individual (PhD training), institutional (support to national doctoral programmes and research centers), and relational (research groups). This can be appreciated both in national and international publications. On the one hand, looking at the figure below, the increase in international publications looks impressive, but the problem is the absolute number, which is very low (2,158 documents published in 2008) compared to other Latin American countries. For instance in 2008 (OCyT, 2009), Brazil published 34,212 documents in SCI journals, Mexico 10,335, Argentina 7,929, and Chile 4,409. Only Brazil accounts for almost 50% of the Latin American scientific production, while Colombia does not reach 3%. Colombia has been improving a lot; the annual rate of increase for the last five years is larger than Brazil and Mexico, but we are still lagging behind.

Figure 14: Colombia scientific publications in SCI journals 1975-2009



Source: Web of Science, SCI Expanded, November 2004 & August 2009.

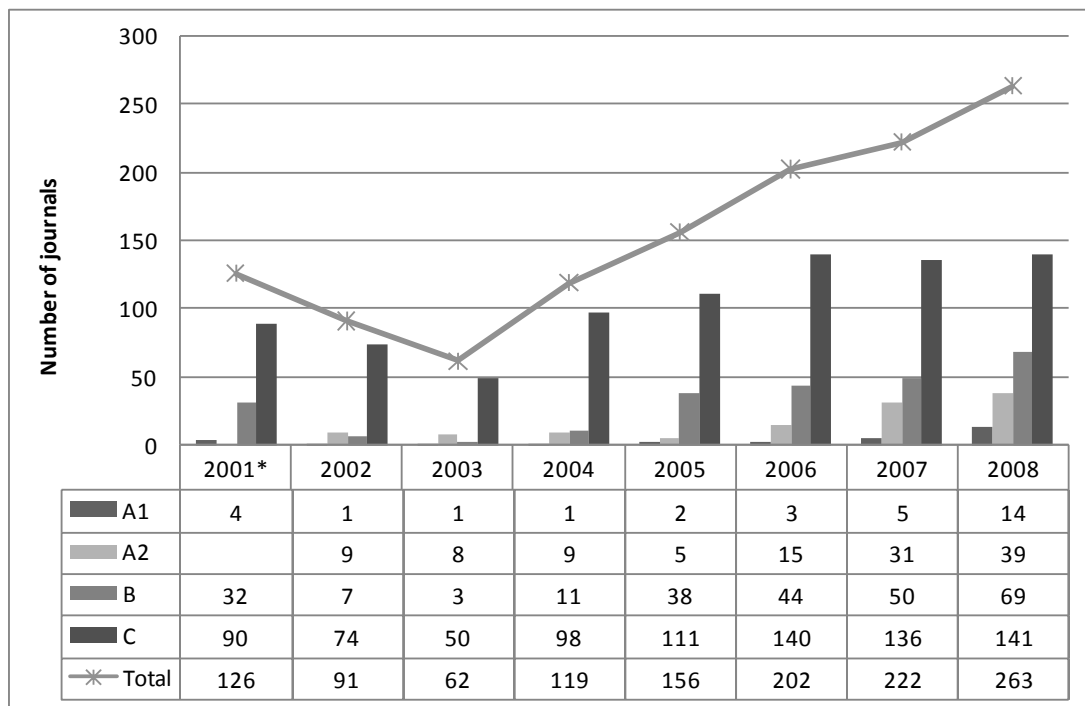
Looking at the figure above, we could try to correlate certain milestones of the evolution of the S&T institutions and policies in Colombia (based on table 4) with scientific publications, attempting to determine if they have had a major impact (breaking trends) on scientific production⁹⁵. For instance, events such as the creation of the Colombian SNCyT in the early 1990s and launching of the ScienTI platform in the early 2000s seem to have boosted the rate of publications. Statistically speaking⁹⁶, when analyzing annual changes there are no obvious turning points, changes are erratic, even if at a glance there is a steady rise.

⁹⁵ There is a renowned figure first developed by Jaramillo and colleagues (2004), in which they tried to depict a cumulative learning curve. Forero and Villaveces (2004) further developed the idea and introduced SCI scientific publications in the Y axis and (as shown in figure 14 above).

⁹⁶ The rate of annual change is erratic, and the average change rate is not significant. Several exercises were done using with this data (polynomial, exponential, chi-square equations, etc.) and none produced significant results.

On the other hand, one should also look at scientific production in Colombian journals, and the best measure is the number of journals ranked in the national ranking, Publindex. In 2001, when the ranking process started there were 4 top journals (A); by 2008 there are 53 journals (A1 and A2). On average, during the period 2002-2008, every year 40 journals comply with the ranking requirements. Besides, some of these journals are also ranked in international citation, indexing and reference systems such as SCI, SSCI, Scopus, Redalyc⁹⁷, and SciELO⁹⁸.

Table 9: Colombian academic journals indexed in Publindex by category 2001-2008



Note: * In 2001 there was just A, B and C categories.

Source: OCyT, 2009a & 2009b; original data Colciencias-Publindex.

Jaramillo, with respect to Colciencias' budget, states that it has allowed “a stable equilibrium of conservation of capacities build, without the possibility of making qualitative jumps” (Jaramillo, 2007, p. 313), or leap-frogging using Freeman and Perez expression (Freeman & Perez, 1988). Forero and Jaramillo further argue that at inferior equilibriums, S&T communities are extremely small,

⁹⁷ Network of academic journals of Latin America, the Caribbean, Spain and Portugal.

⁹⁸ Scientific Electronic Library Online.

they have a vegetative growth, in other words, they can survive (Forero & Jaramillo, 2002). Certainly the data shown in this chapter show an increase in researchers and research groups (i.e. capacities), and publications and journal (results), but there is no increase in the national expenditures in general, and government expenditures in particular (inputs). The universities in particular, have counteracted the diminution of public funding, increasing their own expenditures in S&T, using various mechanisms to fund intramural research. If the country would like to see a leap frog in respect of STI capacities and achievements, more public resources need to be assigned to these activities.

Taking into account the historical information and data presented, one could say that Colombia has a solid and stable National System of Science, Technology and Innovation. Many studies on S&T policy in Colombia (Jaramillo, 2007; Jaramillo, et al., 2004; Malaver & Vargas, 2005; Monroy, 2004; Villaveces & Forero, 2007) show the successes of such policies and the effects they have on the communities, but very few of them have addressed the evolution and functioning of the SNCyT as such. For doing so, the interviews, expert panels, and surveys conducted for this thesis will provide new information and insights that will allow characterizing the interactions between the actors of the Colombian SNCyT and the impact that the organizational arrangement, i.e. Sábato's Triangle, has had in the operation of the system.

4 HYPOTHESES AND RESEARCH METHODS

4.1 The Problem and the hypotheses

Colombia has a solid and stable National System of Science, Technology and Innovation, even if it has a small research community, few innovators, and a small and instable public budget for STI. Why is it so solid? Is it because of the organizational arrangements put into place (that is, Sábato's Triangle used in all decision-making bodies)? This model was proposed to typify the tripartite relations within an S&T system that occur between government, scientific and technological infrastructure, and productive sector, and to analyze national capabilities to formulate and implement a national a strategy in the field of STI.

Many experts believe that the application of Sábato's Triangle has failed in Colombia because no common policy or decision-making has been accomplished over the years, especially when one looks at public policies in which various government agencies should participate. The question is: Has the organizational model had effects other than a national strategy of STI, as the authors pretended? The effects of applying Sábato's Triangle could be of different nature: i) coordinated policy-making; ii) an increase in scientific production (more research); iii) an increase in new products, services and processes (more innovation); iv) construction of social capital; v) dissemination and communication of policies that improve their effectiveness. Communication is not considered thinking about knowledge production, but rather for networking and dissemination of government, industry or university initiatives among peers and colleagues. Considering that the Triangle model is normative, one should not invalidate it based on the desired results of the tripartite relations, but analyze the contributions and effects that the organizational arrangement has had on building the SNCyT, and the mechanisms used to make it functional.

The focus of this thesis is not the content or the outcomes of science, technology and innovation policies but the institutional framework in which they

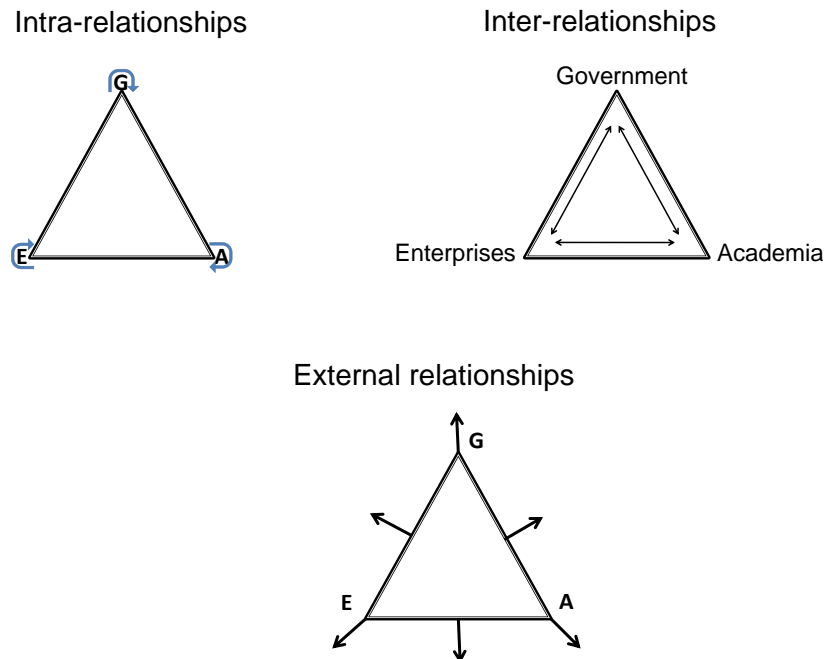
are negotiated and implemented, which determines their effectiveness. We could find studies that show the successes and failures of Colombian research and innovation policies, but few on the evolution and the interactions that occur in the SNCyT. Therefore, the heart of the research will be the SNCyT and its decision-making bodies, and Colciencias as the head of the system. The main objective of this project is to analyze the impact of Sábato's Triangle model on the development of the Colombian SNCyT, looking at its cohesion and the recognition granted by the various actors. In earlier research, I found that the councils of national programmes of S&T (CPNCyT) as such have not been analyzed from a governance perspective, and that analysts and practitioners do not agree on the performance and convenience of the councils. Therefore they became the centre of my analysis.

Sábato and Botana propose three levels of relationships (see figure 15): intra (among actors of each vertex), inter (between vertices of the triangle), and external (with actors outside the national system). For the purposes of this study, not all levels are equally important. The inter-relationships are the most important, also following Sábato and Botana's statement, as it is in the interaction of the vertices that a strategy of STI can be designed and implemented. The intra relationships are also key because a group of actors or vertex needs to develop its own capabilities to do what it has to do, and part of that depends on the articulation of the various actors that belong to each vertex. Finally, with respect to external relationships, even if for Colombia the influence of international agencies has been determinant, to study the impact of those relationships will imply consulting a different group of stakeholders. So that level of analysis will not be considered.

In Colombia the sides of the triangle seem to be not equally "developed" nor are all the desired relationships present. In the Colombian case, one can presume that there are strong links between government and academia, weak linkages between academia and enterprises, and "intermittent" interactions between enterprises and government (see diagram 16). Looking at the relationships between the actors, we can study the networks built between the

three vertices and the communication flows among the various actors. Besides, it seems that there are also coordination problems within each vertex, especially in government, as many analysts have pointed out (Malaver & Vargas, 2005; Monroy, 2004; República de Colombia & Departamento Nacional de Planeación, 2000).

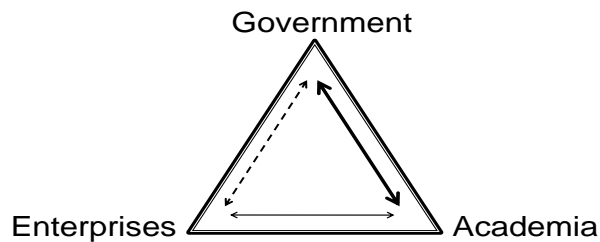
Figure 15: Relationships between actors in Sábato's Triangle



Source: Adapted from Sábato & Botana (1968) and Amaya & Alvarado (1977). Note: G: Government, A: Academia, E: Enterprises.

This thesis aims to answer two main questions: i) What roles have the programmatic councils played in building the Colombian SNCyT?; and, ii) How can we characterize the relationships between the three groups of actors of the Colombian SNCyT, i.e. government, academia, productive sector? Therefore, the general hypothesis aims to establish the overall impact that the model has had on the SNCyT and Colciencias. The specific hypotheses will respond to the two questions mentioned above.

Figure 16: Inter-relationships in Sábato's Triangle: The Colombian Case



Source: Adapted from Sábato & Botana, 1968.

How can we measure and characterize Colciencias' social capital? Generally, social capital studies are done looking at individuals, less common are the studies analyzing organizations, such as Colciencias or the SNCyT. On the one hand, in concordance with Burt, the issue about social capital is performance (Burt, 2000), so when analyzing the effects that Sábato's Triangle has had on the Colombian SNCyT, the effectiveness of the system will be observed. On the other hand, according to Lin, embedded resources are valid measures for social capital, and those resources could be: information, influence, social credentials and reinforcement (Lin, 2001, p. 13). The building of social capital can be observed by studying the groups of actors and the communications, interactions and relationships that have contributed to the cohesion of the SNCyT. Firstly, considering that programmatic councils are central to the SNCyT, an opinion survey will be carried on with councillors (see Appendix B), looking at their perception about the functioning of the councils and their roles. Some questions will try to establish what resources are embedded in the social network, from which social capital can be built. Below are the general hypothesis that guides this inquiry and the specific hypotheses regarding the CPNCyT.

Research hypothesis	Null hypothesis
General hypothesis	
Hi: The model of Sabato's Triangle applied in Colombia has contributed to the cohesion of the SNCyT, building Colciencias' social capital.	Ho: The model of Sabato's triangle applied in Colombia has not contributed to the cohesion of the SNCyT, destroying Colciencias' social capital.
Specific hypothesis	
Hi: The programmatic councils have contributed to STI policy-making.	Ho: The programmatic councils have not contributed to STI policy-making.
Hi: The programmatic councils have contributed to disseminating policies formulated by Colciencias.	Ho: The programmatic councils have not contributed to disseminating policies formulated by Colciencias.
Hi: The programmatic councils have favoured the social construction of norms and values within the SNCyT, developing "common rules of the game".	Ho: The programmatic councils have not favoured the social construction of norms and values within the SNCyT, developing "common rules of the game".

Secondly, the analysis of the intra and inter relationships that are developed between the three groups of actors of the Colombian SNCTI, and the results expected from the development of those relationships, will be done based on in-depth interviews (see Appendix A), expert panels and analysis of statistical data. The characterization of the relationships will be done at the system's level, meaning that particular analysis of the interactions in a specific programme will not be carried out.

Research hypothesis	Null hypothesis
Specific hypothesis in respect of intra-relationships	
Hi: There is articulation and coordination of policies and resources among government agencies.	Ho: There is no articulation and coordination of policies and resources among government agencies.
Hi: Colombia has a strong and cohesive research community with lobbying capacity.	Ho: Colombia has a weak and detached research community without lobbying capacity.
Hi: Colombia has strong producer associations that promote STI activities.	Ho: Colombia has weak producer associations that do not support STI activities.
Specific hypothesis in respect of inter-relationships	
Hi: The academic-research community adopts the policies and instruments of Colciencias.	Ho: The academic-research community does not adopt the policies and instruments Colciencias
Hi: Firms use Colciencias STI policy instruments.	Ho: Firms do not use Colciencias STI policy instruments.
Hi: There are strong, frequent and numerous “university-industry” linkages in Colombia.	Ho: There are weak, rare and few “university-industry” linkages in Colombia.

4.2 Research methods

The methods used in this research are literature review and field work based on in-depth interviews, expert panels, and a web survey⁹⁹. Given the

⁹⁹ There is another input to this investigation, which is my personal experience, since I worked for Colciencias during two periods of time. In the period 1989-1992, when the SNCyT was being set up, I worked on the design of the regional strategy and the launching of the PhD training programme. The second time was in 2007-2008 as a STI policy advisor. In the meantime, I have always been very close to Colciencias, for instance, while working for DNP (1996-1998) I was in charge of Colciencias affaires, and as a DNP delegate I participated in two programmatic councils (industry and basic sciences) and a regional commission (Bogotá). During all this time, I had no clear intention of observing the actors; I was just one more actor. At present, I can certainly look back now and analyze the situation, but from a different perspective. Recently I was invited as an expert to the sessions of the Council of the National Programme of Social Sciences and

framework of Sabato's Triangle model, two main fields of studies will be analyzed to ground the research problem: science and technology policy and communication. The S&T policy approaches to be analyzed are: innovation systems, the Triple Helix model, and principal-agent theory. All emphasize some factors that affect research and innovation activities: the role of institutions; the importance of networks and linkages between actors; social capital development; the dissemination of tacit knowledge; and, the significance of learning organizations. The communication and sociological approaches to be reviewed and analyzed are network theories in general and, more specifically, social networks, social capital, and actor network theory.

The literature review and the consultation process will be complemented with several S&T indicators (some presented in the previous chapter), showing the fragilities and the strengths of the SNCTI, and exemplifying some of the relationships.

The field work has two stages of analysis, as different inquiry instruments will be used to answer the questions posed above and prove or disprove the different hypotheses. The first instrument is in-depth interviews conducted to current and former Colciencias directors, deputy directors and managers of National Science and Technology Programmes, and people very close to the organization. The second instrument is an electronic survey to the representatives of the research community and the productive sector that are members of the programmatic councils. The field work methodology will apply deductive reasoning, working from the general to the more specific. I think this is the best approach, since I need to gather basic information on how the system performs as a whole before I can establish patterns of communication and networking among the actors of the Colombian SNCTI.

The main objectives of the in-depth interviews, complemented with expert panels, are: i) to discover if the communities recognize the existence of the

Humanities, when they were defining the strategic plan 2010-2020. In this case, I explicitly assumed the role of observer.

SNCyT as an institution, ii) to evaluate the performance of the collegiate corps; and iii) to determine the main policy achievements and failures (see Appendix A “Interview guide”, in English and Spanish)¹⁰⁰. Sixteen persons in total were interviewed, of which eleven were (or still are) Colciencias officials¹⁰¹, and four panels with different sectors – government¹⁰², academic/research community¹⁰³, firms¹⁰⁴, and representatives from regions¹⁰⁵ - (with the participation of a total of 24 persons) were conducted in the second semester of 2006. Of a preliminary list of 20 people, 16 accepted to be interviewed. I will make references to their responses by putting into brackets the letter “I” followed with another letter identifying the interviewee (e.g. I-A, I-F); however there is no correspondence of the second letter with their surname or the order of the list in footnote 101. With respect to the panels, it was difficult to get a group of representatives from the productive sector, and somewhat difficult that all the ministries that participate in the SNCTI accepted the invitation. The participants of expert panels will not be identified individually; generally I will make reference to the panel discussion.

The second test of the hypothesis is to ask the researchers and the entrepreneurs members of the CPNCyT, how they perceive their roles in the

¹⁰⁰ The interviews were conducted in the framework of a larger project led by the Colombian Observatory of Science and Technology for Colciencias. The project was titled “Evaluation of the SNCyT and the NSI”. I was in charge of an expert inquiry on STI policies and institutions. The results of the project were not published and only Colciencias knows the reports.

¹⁰¹ The interviews include Colciencias’ general directors: Fernando Chaparro, Clemente Forero, and Margarita Garrido; deputy directors: Jorge Robledo; José Luis Villaveces, Campo Elías Bernal, Hernán Jaramillo, and Mauricio Nieto; and managers of national programmes: Juan José Plata, Miguel Tobar, and Galo Tovar. Even if their names are here mentioned, in the analysis chapter no personal reference will be made because of confidentiality reasons.

¹⁰² From government, the ministries of Communication, Agriculture, Industry and Environment attended the invitation. The ministries of Energy and Mining, and Health did not participate.

¹⁰³ Twelve persons were invited and seven attended; the following people participated: former Vice-chancellor for Research of *Universidad de Antioquia*, former Vice-chancellor for Research of *Universidad Nacional de Colombia*, Director of Cenicafé, Research Coordinator of the Law Faculty of *Universidad del Rosario*, Director of the *Instituto Pensar* at *Universidad Javeriana*, Director of CIDEIM (health research centre), General Director of INVEMAR (sea sciences research centre).

¹⁰⁴ Nine people were invited, and five attended: President of Innovation Foundation (private non-profit organization), Tratar CEO, GestiónTek general manager; Artífice manager; Escobar y Martínez CEO (all private firms).

¹⁰⁵ From the regions, I invited members of the Codecyt from twelve departments (all of them from the academia/research community), of which seven accepted the invitation: Santander, Cundinamarca, Cauca, Atlántico, Caldas, Tolima, and Chocó.

SNCTI, how they have contributed to the development of the SNCTI, and track the information they receive in the council sessions. This will be done by applying an electronic survey (the English and Spanish versions of the survey are in Appendix B) to current and former members of the councils from all programmes.

A list of all members (past and present) from the research/academia and productive sector spheres was prepared, based on a consultation with Colciencias managers of national programmes. The process of collecting this information took between a day and a month, meaning that some Colciencias managers have this data well organized and available; for others it was an extra task to gather it; besides data for the S&T health programme was not given by Colciencias. A preliminary list of around 220 councillors was prepared, where not all the former councillors were traceable (Colciencias did not have the coordinates of around 50 people); their personal data has been lost (telephone number, e-mail, institutional affiliation, etc.) over the years¹⁰⁶. With their full name and S&T area of interest, I attempted to identify their current coordinates, but it was not possible for everybody. For members from the research community was easier, using their area of performance (the programmatic council) and the institutional affiliation at that moment; generally they do not change that affiliation that often. That is not the case of the representatives of the productive sector, who were very difficult to track. The survey was sent to 186 people, and 74 responded to the survey, equivalent to a 40% response rate (see table 10 for basic demographic data of the respondents). Taking into account that the survey included open questions, when quoting those responses I will cite the person surveyed starting with the letter “S” followed by a number, which corresponds to the order in which the councillors answered the survey (e.g. S1, S25, S63).

The participation by gender (73% men and 27% women) in the survey follows the pattern of national data regarding female participation in STI activities. Based on the annual S&T indicators published by the OCyT, the distribution of the total number of active researchers in Colombia is: 62% male, 38% female.

¹⁰⁶ Colciencias loss of former councillors' coordinates is a sign of destruction of social capital.

This distribution becomes more unequal when looking at the leaders of research groups: 69% of active research groups are led by men, while 31% by women (OCyT, 2009a, 2009c). It is safe to assume that the distribution by sex at the programmatic council level gets more uneven¹⁰⁷, taking into account that these people are the top researchers in their area, and there are usually many social and cultural factors (e.g. the “glass ceiling”) that make it more difficult for women to ascend in their scientific careers and to obtain recognition.

Table 10: Respondents by gender and type of councillor

	Male	Female	Total	Researchers	Entrepreneurs
Total surveyed	137	49	186	127	59
Respondents	54	20	74	61	13
Rate of response (%)	39	41	40	48	22

Source: Councillor survey.

The distribution of the people surveyed by type of councillor, either representative of the productive sector (18%) or the academic/scientific community (82%), did not keep the pattern of the current distribution. Today the members of the CPNCyT are 52 researchers (67%) and 26 entrepreneurs (33%). Certainly, part of the problem is that former councillors from the productive sector were very difficult to find.

The number of councillors per programme is not equal, on average there are five councillors from the academic/research community and two from the private productive sector. Councillors in principle are elected for two years and can be re-elected for one more period. Sometimes their renovation takes a bit longer, thus some of them have been members of a council for more than four years. Also, based on the survey results, 65% of them have been re-elected.

¹⁰⁷ For instance, the participation of women in the CNCyT during the period 1991-2005 is much lower. Taking into account all members (government officials, and representatives from the research community, the regions and the private sector) women account for 19%; considering only researchers, their participation increased a little bit, to 21%; but during that period no woman has represented the private/productive sector (OCyT, 2006).

Table 11: Respondents by S&T national programme

PNCyT	Total surveyed	Respondents	Rate of response %
Basic Sciences	16	10	63
Social Sciences	10	6	60
Health	16	4	25
Enviroment	25	4	16
Education	21	9	43
Sea Sciences	31	13	42
Biotech	15	9	60
Energy & Mining	9	8	89
Agriculture	7	4	57
Electronics telecom & informatics	7	4	57
Industry	29	3	10

Source: Councillor survey.

It was not possible to identify all former councillors for every PNCyT. Therefore, the rate of response between the programmes is not comparable. However, there are few things to highlight from the table below. First, the high response rate in four programmes: energy and mining, basic sciences, social sciences, and biotechnology. The lowest rate of response is found in the programmes of industry and environment. The largest number of respondents is in the sea sciences programme, followed by basic sciences, education and biotechnology. The fewest respondents are in industry, and four other programmes have the same number of respondents. Taking these two dimensions, it seems that councillors with stronger ties to the SNCTI are from basic sciences and biotechnology, and the least from industry.

Table 12: Respondents by Colombian department/province

Department	Bogota	Antioquia	Valle	Cundinamarca	Santander	Magdalena	Rest of the country	Total
Respondents	22	17	8	7	4	3	13	74
%	29,7	23,0	10,8	9,5	5,4	4,1	17,6	100,0

Source: Councillor survey.

The regional concentration of responses is not a surprise. STI activities, institutions, researchers and innovative firms, are concentrated in Bogotá, the national capital, (which is situated in the department of Cundinamarca), Medellin (the capital city of Antioquia) and Cali (the capital city of Valle). The only number that is remarkable is the case of Magdalena, the department with the largest R&D centre oriented towards sea investigation, a programme with a large number of respondents.

5 ANALYSIS OF INTERVIEWS AND SURVEY RESULTS

In this chapter I will discuss the evidence gathered through the various sources – interviews, expert panels, web survey, and S&T indicators - and I will try to prove or disprove the research hypotheses, formulated in the former chapter. I will first present the case of the programmatic councils, and then describe on the relationships and interactions between the three groups of actors that compose the overall Sabato's Triangle of the Colombian SNCyT.

5.1 The Role of the Programmatic Councils –CPNCyT

Let's review the composition and functions of the programmatic councils. Councils comprise members of the academic/scientific community, the productive sector and government agencies. Their main tasks are: i) definition of plans and policies for their sector or field; ii) project funding; and, iii) articulation of financial resources (see section 3.3.). Assuming that the CPNCyT are research councils, Slipasæter and colleagues say that a research council could perform several tasks:

Towards the scientific community, a council main role will normally be as a funding agency for research projects, but it might also serve as a developer of research policy through choice of instruments, priority areas and its selection mechanisms. Towards policy-makers, it will act as an agency implementing policies (Slipasæter, Lepori, & Dinges, 2007, p. 402).

The CPNCyT are still seen as Colciencias programmes and not really as national ones (I-F)¹⁰⁸. This is due in part because the technical secretariat is primarily and exclusively in the hands of Colciencias, and because the councils only “control” Colciencias’ budget. Some of the criticism against the role performed by the councils is that they focus mainly on the approval of projects and not much on the formulation of policies (I-J), and that they have not yet

¹⁰⁸ Just a reminder that “I-F” means that I am quoting the “F” person interviewed. I will make reference to the people surveyed as “S3” or “S45”.

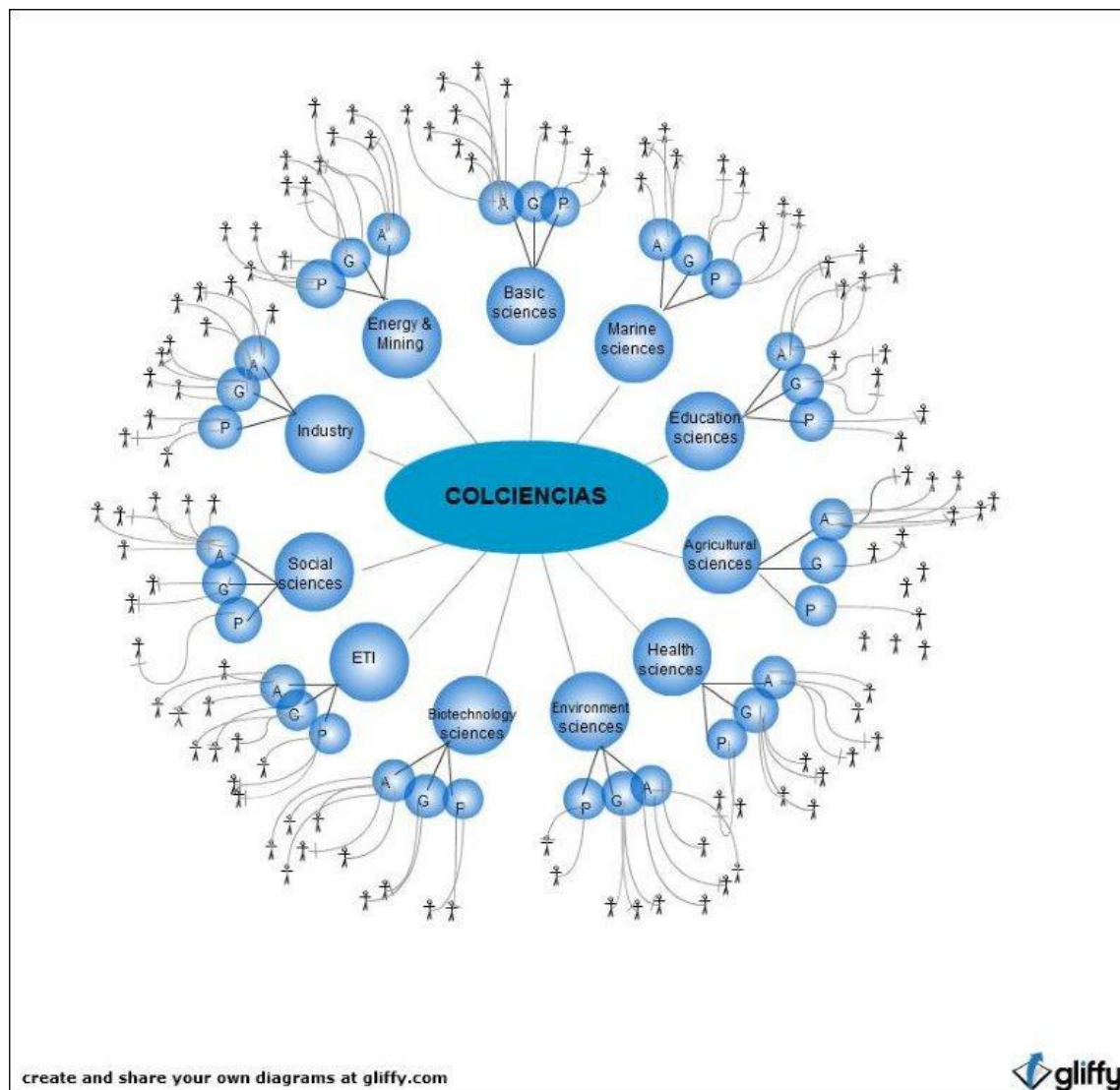
developed a long-term vision (I-M). Also, the representatives of the ministries perceive that the programmatic councils are more responsive to the research community than to the government. On the contrary, Slipasæter and colleagues, say that research councils need to be responsive to both to fulfill their mission (Slipasæter, et al., 2007, p. 403).

5.1.1 The circulation of information: ideas and policies

The organizational chart of the Colombian SNCyT is usually presented in a hierarchical way (see Figure 12). However, keeping in mind that the SNCyT is composed of various networks, such as the CPNCyT, the system could be represented differently, depicting every member of the CPNCyT (see diagram below). In this map there are “invisible” persons, such as Colciencias’ directors, managers and staff of every PNCyT. When doing a proper social network analysis, these people, and how they are linked to councillors, will need to be put in the map. But since we are more interested in the role of CPNCyT as a mechanism for the circulation of ideas, people and policies, this type of map illustrates the point, showing the large number of agents that help to disseminate Colciencias initiatives. The analysis of the CPNCyT presented in this document, could be related to the idea formulated by Etzkowitz and Ranga¹⁰⁹, who look at three different spaces in the Triple Helix model, linking knowledge, innovation, governance and leadership; these spaces are: knowledge, consensus and innovation (Etzkowitz & Ranga, 2010). Therefore, the councils could be considered the consensus building spaces of the Colombian SNCyT.

¹⁰⁹ Theme paper of the Triple Helix VIII Conference, held in Madrid (Spain), October 20-22 2010.

Figure 17: The SNCTI as a network



Source: Prepared by the author. Notes: A. Academia; G: Government; P: Productive sector; ETI: Electronics, telecommunications and informatics.

Several questions on the survey were designed to illustrate the communication aspect. In the first place, the question regarding the benefits they perceive as a councillor (see Table 16), 40 out of 74 (54%) chose “acquire and transmit valuable information”, the second most frequent option. In the second place, councillors were asked with whom they share the information they receive in the council meetings, and the use they give to that information. 63 out of 74 persons (84%) responded that they share it with colleagues within their organizations, and 39 (53%) with colleagues outside their organizations (see

Table 13). Finally, with respect to the use they give to that information, 60 people (81%) use it to strengthen their academic discipline, and 50 (68%) use it to formulate research or innovation projects. It is worth noting that councillors do not influence their organizational environment (18%) as much as their academic discipline (see Table 14).

Table 13: Sharing of information

With which groups do you share the information that you receive in the meetings of the council? (two options)	Responses	%
You keep it to yourself	13	18%
You share it with colleagues within your organization	63	85%
You share it with colleagues outside your organization	39	53%
You share it with your family	3	4%
You share it with your bosses	6	8%
You share it with your students or assistants	17	23%

Source: Councillor survey

Lin states that the facilitation of the flux of information is one of the factors that makes social capital work. And following Everett Rogers' arguments related to homophily, information sharing is certainly facilitated in the programmatic councils because it happens between similar people, mainly scientists (the majority), who are either councillors or Colciencias PNCyT managers. Lin adds: "In the usual imperfect market situations, social ties located in certain strategic locations and/or hierarchical positions (and thus better informed about market needs and demands) can provide an individual with useful information about opportunities and choices otherwise not available" (Lin, 2001, pp. 6-7). Based on the responses, it seems that being in the "inner circle" of the SNCTI, that is the CPNCyT, is a privileged position that helps the councillors and their closer contacts (ties) present R&D projects and take advantage of that position.

Table 14: Use of information

How do you use the information you receive at the council sessions? (choose two options)	Responses	%
Influence the strengthening of your academic discipline	60	81%
Formulate and present research or innovation projects	50	68%
Formulate institutional projects, plans or strategies	13	18%
You apply or use it for your personal benefit	7	9%

Source: Councillor survey.

Looking at the answers provided by the councillors to the question related to the most frustrating thing or difficulty they perceive, they mention that their policy recommendations are not taken into account, that there is no communication or articulation with “higher” levels, that is, the Director General of Colciencias and the national council; which means that the information flows in one direction (top down), but not upwards. In addition to the top-down communication problems, there are also lateral problems, as mentioned by one of the people surveyed (S43), referring to the fact that there are no relationships between programmatic councils. One of the Colciencias managers interviewed (I-C) recognized the disarticulation between the CNCyT and the CPNCyT. Below are some of the councillors’ comments:

- “The most frustrating thing is that the themes, priorities and recommendations that are discussed within the councils do not translate into policies or calls for proposals. There is neither communication with superior instances in Colciencias nor feedback” (S44).
- “Too little time [i.e. the period] to perform as a councillor and, later, not to be taken into account for future developments” (S69).
- “They always told us to contribute to the definition of policies but they never took our opinions into account. I think the councils’ tasks towards this end should be formalized” (S9).

Information is one of the resources embedded in social networks, therefore taking into consideration the results of the survey; it seems that the councils are a suitable mechanism for disseminating information from Colciencias to other

actors of the system. Councillors state that they share information with their (supposedly) closer ties, which are their colleagues.

5.1.2 The council's tasks

There are contradictory opinions regarding policy-making as one of the council's functions. Some councillors surveyed affirm that councils contribute to STI policy-making in their respective area, but others say that they do not have enough time for it and that when they make proposals they are not taken into account. Generally they view their contribution as setting priorities via the selection and funding of projects. What councillors enounce as the major contribution of the council to the development of each S&T programme, is key to understanding what they think about their main functions; in their words:

- "Feeling that one can help to improve STI recognition and contribution to economic and social development, by proposing policies, strategies and incentives based on i) the identification of barriers and frictions that the scientific community perceives; ii) learning about the needs of the productive sector; and, iii) national and sectoral policies" (S43).
- "The promotion of research in health, resource allocation, analysis of the pertinence of research, participation in policy-making, strengthening of the evaluation processes of research proposals with international and national peers, all these improve national capacities" (S69).
- "Decision-taking about project funding priorities" (S25).
- "Validation of pertinence, quality and viability of research projects under its examination" (S23).
- "Contribution to the development of research and innovation policy on education (S4).
- "Contribution to the definition of strategic lines and priorities" (S5).
- "We are councillors, our main function is to help, advise and listen, so that the manager of the programme can decide" (S12).

The open questions regarding satisfactory and unsatisfactory aspects of their role also tell us something about their functions. The most satisfying things

for councillors are: to participate or contribute to the formulation of plans and policies, to know about the SNCyT, the national policies, what is being investigated in the country, and the research communities. Meanwhile, many councillors (46%) point out that one of the frustrations or difficulties they face is lack of time to formulate policies or design implementation strategies. Councils do not meet very often, every three to four months, the sessions are not long enough, and there are usually projects to be considered. In this sense, the comment made by Stein and colleagues is appropriate, when they say that “good policymaking can be facilitated if political actors have relatively long horizons, and arenas for discussion, negotiation, and enforcement of political and policy agreements are relatively encompassing and well institutionalized (Stein, et al., 2006, p. 141). Besides, one of the councillors clearly states that the membership period is too short (S66).

The experts consulted state that the existence of the CPNCyT cannot be justified merely for project selection. In the interviews and panels, participants state that in practice the councils have little power because they do not manage resources from other entities different from Colciencias, they do not have the power for the coordination of the public resources oriented towards science and technology (I-C, I-D). Current and former Colciencias officials consulted would like councils to discuss policy but, as councillors say, Colciencias does not provide the time and space to do so. I wonder, then, if Colciencias really expects CPNCyT to formulate STI policies in their own field, or only implement and apply national guidelines and strategies to the specific area? Certainly councillors claim to be allowed to design policies and strategies, even if some of them give importance to the selection and approval process. Representatives of the ministries argue that if the CPNCyT dedicate themselves only to project approval, the ministers will never get involved. They propose that the councils should be focused on negotiating resources, calls for tenders, and policies with other public and private entities.

Councillors were asked about the real key functions of the programmatic councils (see Table 15). The most important are: “to approve or recommend

project funding” 62 out of 74 (84%); “to define funding priorities” 32 out of 74 (43%); and, “to formulate research and innovation policy for the programme” 26 out of 74 (35%). It is interesting to note that sharing information between diverse actors is not considered a central function of the council (selected only by 3 people; see Table 15), but rather a by-product of their activities, as most say that they share the information they receive in the council’s meetings, rather than keeping it for themselves (see Table 13).

Table 15: Key real functions of the CPNCyT

What are the key real functions of the programmatic councils? (two most important)	Responses	%
To approve or recommend project funding	62	84%
To define funding priorities	32	43%
To define main research lines or topics of the Programme	1	1%
To formulate research and innovation policy for the Programme	26	35%
To coordinate S&T policies with other policies	6	8%
To share information between diverse actors of the SNCTI	3	4%
To discuss national priorities	6	8%

Source: Councillor survey.

When asked about changing the functions of the councils, 54% of the councillors say that they should be changed to include policy-making and 46% say that they should not be changed. Many acknowledge that what the law stipulates is correct, that what needs to be changed is the operation of the councils, making better use of their advice. Even if more councillors would like the functions to be changed, the changes proposed aim to formalize the formulation of policies, which is a task already included. Below are some quotes from those who did not see the need to change the existing functions:

- “The functions on paper are ok, the problem is in the execution, and the slowness of what happens” (S6).

- “The council is a group of experts who discuss and advise the SNCyT on the guidelines and research priorities of each sector (programme), in this context, the tasks are well defined” (S1).
- “The functions on paper are fine, however in practice it’s limited to the approval of projects and, basically, very little is left to the ones that in ‘theory’ we should be performing. The passivity of Colciencias puts a constraint on many of the council’s initiatives” (S37).
- “In general the functions of the CPNCyT are well defined; the important thing is that their recommendations should be incorporated into government policies and plans” (S50).
- “It’s important to make a serious evaluation before changing functions so it doesn’t end in artificial reductionism. The problem is not the functions but the conditions that make it possible to accomplish them” (S59).
- “I think that the functions are adequate; however, what must be improved is the council’s operation” (S70).
- “I consider [the functions] as adequate in ‘theory’; the problem is that they aren’t necessarily met, due to the immediate need for project approval” (S73).

In the same line of discussion, following are some quotes from those who think the functions of the CPNCyT need to be changed, but did not propose new functions:

- “The councils must develop a more active position in the definition of research and innovation policies, and their decisions must be binding in nature. The time the councillors put into this task must somehow be recognized by the institution they come from, by means of an agreement between those institutions and Colciencias” (S24).
- “[The change is] not only with respect to their functions but also how they operate. In fact, the functions of these councils are what I responded in the previous question [Decision-taking about project funding], however, the councillors, together with other researchers, should be defining research priorities in Colombia and significantly supporting the programme, with regard to the formulation and actualization of policies, in concordance with the national and international contexts” (S25).

- “The formulation and coordination of sector-specific research policies and their financing must be prioritized, which gives coherence to the government’s work, seeking national impact.” (S10).
- “The councils should be more strategic and less operational (S20).

There are two well defined functions: selection of projects and funding allocation; and generally councillors give importance to these tasks. Though, there are contradictory results with respect to the contribution of policy-making: some say that they do it (35%). However, I would argue that this is done partially and occasionally, when the strategic plan of the programme is being prepared, every four to six years. But in their daily routine they do not formulate policies, although they would like to.

5.1.3 Tripartite representation in the Councils

Sábato’s Triangle model seems adequate as an operating arrangement. It includes the three institutional sectors that should participate in the orientation of STI policies and strategies, although in Colombia it is not a representative stakeholder scheme. One could say that if the councils are to be changed, three different aspects should be considered: functions; representativeness and election mechanisms; and their relationships with the government, specifically Colciencias (principal-agent issues).

One of the interviewees states that the CPNCyT conceived as triangles of interaction has resulted in very unequal vertices: a very strong and participative academic sector, a practically inexistent or passive (depending on the program) productive sector, and an uncommitted state without continuity and, on some occasions, underrepresented (I-B), due to the delegation in medium to low-ranking government officials. He further argued that the principle continues to be important but it is necessary to put it into practice in a different way. Similarly, one of the persons surveyed (S26) says that councils are a “necessary evil”. Some of the experts consulted consider that it is necessary to rethink the programmatic councils, since it seems that the mechanism has been exhausted.

In the panel with representatives of the research community, a participant said that councillors-investigators should be there representing 'science', and have an academic and not "syndical" nomination. This statement is not clear to me, taking into account that these people are nominated on the basis of their merits. However, as one of the people surveyed states "the CPNCyT bring together various 'interest groups'. As such, these groups will try to take advantage for their own benefit" (S26). Certainly, any individual councillor has interests, and he/she tries to "represent" his/her discipline, organization and region, but very few of them acknowledge this situation (S16, S26).

The councillors' perspective is different, from that of the experts consulted. They think that the councils work, despite the lack of time to formulate policies. They believe that the council's composition is correct, 77% say that the composition should not be changed, and that the election mechanisms should not be modified (68%). Some say that the articulation of the three sectors is an advantage (S45, S58). Not many explicitly identify Sabato's Triangle but some (16%) state that the most satisfying things are: the possibility of sharing experiences and points of view, and relating and communicating with others who are different from them. For instance, this is how they refer to these tripartite relationships:

- "To know and to establish relationships with other people interested in the policy and social issues of STI" (S19).
- "To establish contact with other persons from the academic, productive, and governmental sectors in our area" (S21).
- "The participation of different professionals with diverse academic, entrepreneurial, political and regional backgrounds with high technical and human qualifications, that generate a good environment to produce recommendations that to a greater extent, will contribute to an improvement and optimization of the research and innovation results in the country" (S45).
- "The personal contact with other councillors" (S28).

- “It’s a scenario (PNCyT) where researchers, business people and the research institutions meet and, if fully taken advantage of, the research that is conducted in the country would have greater relevance and exploitation” (S58).

Additionally, with regard to the perceived benefits of being councillors, 62 out of 74 (84%) select “exert influence in the scientific and technological national development” (not the agents). It seems that the benefits of Colciencias’ social capital are appropriated collectively, and not individually. The options “certify social credentials” and “reinforce identity and recognition” were chosen by zero and three people, respectively. Generally speaking, Colombian society is very politically correct, so *a priori* some people warned me that it was going to be difficult to get councillors to accept that they could benefit from their position, and that personal interests maybe involved.

Table 16: Benefits for the councillors

What benefits do you receive or perceive as a councillor? (three options)	Responses	%
Acquire and transmit valuable information	40	54%
Exert influence on agents from the SNCTI	21	28%
Exert influence in the S&T national development	62	84%
Certify social credentials	0	0%
Reinforce identity and recognition	3	4%
Know more about the SNCTI and research and innovation policy	40	54%
Represent your institution of research community	30	41%
Help to maintain funding equilibrium for your institutions, region or academic discipline	12	16%

Source: Councillor survey.

One of the questions deals with the mechanisms for the appointment of councillors. Most of them (67.6%) state that the current mechanisms are correct, that is, the candidates are nominated by the Colciencias Director and appointed by the CNCyT (this is the procedure that has been followed until 2010¹¹⁰). Of the 24 respondents who proposed changing the process, 8 think that councillors should be either elected within their organization or in formal representation of

¹¹⁰This task is not included in the functions of the new national advisory S&T council.

their institution, and two say that the Colciencias Director should elect them directly. The rest of the people proposed various things, such as in representation of their regions or associations (but not institutions), elected or nominated by the scientific community, by an open call, etc.

Based on a variety of different views, it seems that the tripartite participation in the programmatic councils is adequate, in the sense, that it provides a space for interaction, coordination and articulation, even if no formulation of policies and plans actually happen. As different interest groups get together and take decision jointly (on projects and funding), a common space is facilitated for discussion and negotiation. Most of the criticisms are either related to operative aspects (routine tasks and lack of time) or to principal-agent conflicts and tensions; mainly due to the disrespect to the functions and roles assigned to the councils (agents) by Colciencias (the principal). The structure-agency dichotomy presented above, when analyzing the CPNCyT seem not be solved; taking into consideration that the structure provided by the legal framework is very powerful regulating actors, but certainly in the everyday practice and the setting up social norms and rules councillors and Colciencias' official recreate what the law says.

5.2 The three institutional sectors of Sábato's Triangle

In this section, we will be looking at the intra-relationships, analyzing how articulated and coherent the actors are within their sector. Information and data about two of the three groups of actors was more easily gathered (i.e. government and academia), but it was difficult to illustrate the case of the productive sector.

5.2.1 Coordination of governmental agencies

I will analyze the relationships between governmental agencies looking mainly at two different aspects: the joint policy-making and the coordination of resources. First of all, the SNCyT as such is recognized, as operational, by the

representatives of the ministries who intervened in the panel, despite the lack of articulation between Colciencias and other public agencies. One of the representatives of the ministries asks Colciencias “to speak on behalf” of the whole system, representing all institutions that comprise the SNCTI, instead of trying to concentrate and control everything”. Thank to the inclusion of the executive branch in every instance of the SNCyT, Colciencias has gained greater status and influence within the Colombian state apparatus, but the participation of public agencies is still marginal in the SNCyT. Part of the problem is the representation of the ministries in the councils, the delegates - low to medium rank individuals with little power- limit themselves to approving projects and do not attempt to articulate proposals between Colciencias and their respective agencies. In this sense, the experts perceive a passive participation by the ministries, whereas they say that some organizations, such as universities and R&D centres, get actively involved with the system and adopt the policies formulated by Colciencias.

There are diverging positions about the coordination of the public budget for STI. On the one hand, experts consulted would like Colciencias to coordinate public funds for research and innovation, that is, to centralize their management. On the other hand, the ministry representatives consider that this is not necessary, that the articulation of criteria and policies is what counts, and that the administration and management of resources should continue to be decentralized. It is clear that administration of the public budget involves political power and the institutions will not give it up easily.

During the in-depth interviews, experts mention that STI funding has been successful in primarily two areas: external credits with the IADB and the articulation of resources from other institutions. Regarding the latter, they mention the creation of the Health Research Fund, and the public calls for proposals made in the past together with the Ministries of Communications, and Mines and Energy, some utility companies (e.g. ISA, Codensa), and the national public oil company (i.e. Ecopetrol). Even though the experts consider that actions like these are positive, they are sporadic and very difficult to maintain. The case

of the Ministry of Agriculture is special, because the Ministry usually invests more money in its field than Colciencias invests in all S&T fields, and it has tried to set up its own research system. Recently a harmonization of criteria and processes has occurred between Colciencias and the Ministry, regardless of whether or not they make joint calls for proposals. Thus, we could now say that the Ministry of Agriculture is part of the Colombian SNCTI.

With respect to IADB loans, many of the experts interviewed say that the loans are crucial, because “it is easier for the multilateral banks to convince government officials from the Ministry of Finance and DNP about the importance of STI, than it is for Colciencias’ officials” (I-B), and “their proposals are taken more seriously” (I-D). Drawing on these statements, it looks as if an external actor is needed, so as public organizations coordinate actions and look in the same direction, i.e. the support for STI activities.

The participants in the research community panel consider that Colciencias is absolutely necessary for the country and must be strengthened. Nevertheless, the role of the DNP was questioned with the argument that it has not given the entity the position that it deserves, and that it treats Colciencias like a low level entity. The underlying problem is that the DNP has not understood what STI can do for the country’s development, and that the generation of high level knowledge is the primary benchmark for making national science and technology an effective component of Colombian social competitiveness and development. The research community perceives Colciencias as a third level institution within the State apparatus, taking into consideration that up until 2009 it depended on the DNP. They also question if Colciencias is responsive to the government or to the research community – a typical principal-agent issue, viewing Colciencias as the intermediary. They also criticize the lack of coordination with the Ministry of Education. They think that Colciencias should be strengthened and given a higher status. This will give Colciencias greater possibilities for negotiating budget and legal issues with ministries and other governmental agencies.

The analysis of the interactions between actors of the Colombian system differs if we are looking at the overall system or at the programmatic councils. The policy issues are clearly seen at the national or system's level, where the national policies are designed and negotiated. Today, twenty years after the SNCyT was created, national STI policies are still seen as Colciencias and not truly national covering various ministries and agencies involved with STI; and the same applies for the PNCyT, which are still regarded as Colciencias' programmes, not really articulating government agencies with the other two sectors¹¹¹. The coordination of these agencies has had an occasional articulation of public funds, but no common policy-making.

5.2.2 Is there 'a' research community?

Many argue that the research community in Colombia has no lobbying capacity and no political power (I-L). One could provide some examples, such as when an "outsider" was appointed as Colciencias General Director in the late 1990s, or when the Doctorate Commission was closed, events which did not seem to hurt the scientific and academic community, or the country, in the opinion of one of the experts in the panel with researchers. With regard to the budget cuts in Colciencias, and therefore the funding of SNCTI, the changes in the structure of the entity and other recent reforms reveal that the scientific community has been weak, since it has not been able to stand up and defend Colciencias and the SNCyT. It is said that there are scientists but no research community. As one of the interviewees says: "Unfortunately, there has been a lack of mobilization on the part of the scientific community to 'fight' for allocations in the national budget" (I-G). Some analysts characterize this situation by saying that the disconnect between S&T and politics has hurt national scientific and technological development, since it does not provide any votes, has no political

¹¹¹ In the preparation of the most recent CONPES document for STI policy (3582/2009), DNP made a great effort to call all agencies related to STI. It could be argued, that is the very first national policy that assigns responsibilities to various agencies and not just to Colciencias.

cost, and has no visibility (I-D). S&T has no political mourner, as one of the interviewees says (I-I).

In the panel with the research community, some participants were highly critical of the roles played by researchers working for Colciencias, as if they were not true to their original community, somehow penalizing the 'alternation' or revolving door.

There are differing views about the cohesion of the research community. On the one hand, it is clear that it has no lobbying capacity and no political influence. On the other hand, when looking at the group, the research community is well defined and it is well represented in the SNCyT, not only in quantity -two thirds of the councillors are scientists- but also in quality of representation (people nominated by their merits). A specific factor contributes to a proper representation: researchers are more visible thanks to their publications, conferences, etc. This situation changes a lot when observing the case of the productive sector. Besides, the cohesion of the researchers was also observed in the speech similarities, looking at the responses of the open questions of the survey.

5.2.3 Innovation and the productive sector

In 2007, Colciencias became heavily involved in the discussions of the National Commission of Competitiveness, composed by: the President of the Republic; several ministries; directors of government agencies, such as DNP, SENA, and Colciencias; representatives from the productive sector, and the academia. This Commission is coordinated by the Competitiveness Presidential Advisor, and has the support of the private council of competitiveness, comprising only the productive sector¹¹². The goal of Colciencias' participation was to make entrepreneurs and government understand that economic development and competitiveness without research and innovation was not

¹¹² With the recent change of government (August 2010) the Commission is not longer active, but it has not been officially dissolved. The former president of the private council, was appointed as the General Director of DNP.

possible, at least not in the long term. The final result of this process was that STI were incorporated as the basis for the long-term national competitiveness strategy called Vision 2032. Even if this achievement is perceived by some as staying at the level of the discourse, it has certainly put STI on the agenda, not only the public agenda, but also among entrepreneurs.

To analyze the intra-relationships between the actors of the productive sector, it would have been interesting to have data regarding alliances between firms in relation with STI activities; but the second and third innovation surveys conducted in Colombia did not gather that kind of information. From these surveys one can conclude that a third of manufacturing firms are innovative (33.7%). However in the development of innovation activities, they do not relate with other firms, universities, or technological development centres. Besides, these firms show many of the characteristics (Malaver & Vargas, 2005, p. 59) observed in various Latin American countries, as Salazar and Holbrook have noted: informal organizational settings for conducting innovation; fewer R&D projects undertaken; innovation mainly based on the acquisition of technology embodied in capital equipment; the importance of organizational change in innovation processes; fewer resources devoted to innovation activities; and fragmented flows of information within national systems of innovation (Salazar & Holbrook, 2004, p. 256). Certainly Colombian firms do not have a high propensity to innovate based on the production or adoption of new knowledge; they usually do process innovation through the acquisition of machinery and equipment, rather than investing in R&D or training of personnel (DANE, DNP, & Colciencias, 2005; Salazar, 1998).

Data from a research project¹¹³ conducted by the Colombian Observatory of Science and Technology shows that 23 out of 109 private non-profit research and technological development centres and NGOs -that also do STI activities-¹¹⁴, have been created or supported by the productive sector, either producer

¹¹³ The project's title is "Design and implementation of a characterization model for private research and technological development centres"; the final report was submitted to Colciencias in July 2010. The results have not yet been made public.

¹¹⁴ Not all of these 109 institutions are fully dedicated to R&D, around 60 of them are.

associations or chambers of commerce. Monroy, in her findings related to the interactions between the actors of the Colombian SNCTI, found that producer associations interact equally with R&D centres, and chambers of commerce and other producers associations (Monroy, 2004, p. 57).

As a conclusion, Colombian producer associations, especially in the manufacturing industry, have undergone a process of transformation, becoming more involved with STI activities and organizations. In the agricultural sector, this is not new since most of the R&D centres were created by their producer association (e.g. coffee, cane sugar, flowers, etc.). Therefore, one could say that Colombian has strong producer associations that promote STI activities. In addition, with all the discussions that took place in the National Competitiveness Commission, we could say that more and more the productive sector in Colombia is being persuaded of the need to invest and undertake STI activities, as a mean of being more competitive.

5.3 Inter-relationships between the three groups of actors of the Colombian SNCyT

In this section will be looking at interrelationships, which are essential for the success of any model; it is in the interaction between the three sectors that the self-decision capacity to adopt and implement a national S&T strategy takes place. Again, to illustrate the situation with the productive sector has not been easy.

5.3.1 Government - Academia: the strong link

Let's start with some data regarding Colciencias' distribution of moneys and project funding, by institutional sector (OCyT, 2009a, 2009c). During the period 2000-2007, Colciencias funding was primarily directed to the academic/research community; 71.7% of its expenditures went to universities and R&D centers (universities alone received 52.3% of the funding), while the business sector received only 17.4%. This funding is primarily oriented to

projects and scholarships. Looking at the number of projects approved, the concentration gets worse: universities and R&D centers account for 82.8% of research and innovation projects funded by Colciencias, while firms executed 6.8% of the projects. However, if we look at the STI activities funded, not the direct beneficiary, the picture changes a bit: R&D accounts for 35% of the funding, training of personnel 27% and innovation 18% (source: Colciencias internal records). These numbers coincide with the distribution of Colciencias funding by policy strategy. The national research and innovation policy (Colciencias, 2008) defines six strategies:

- To increase the number of qualified researchers.
- To strengthen STI capacities.
- To support the productive transformation of the country.
- To strengthen the national system of research and innovation.
- To promote social appropriation of science and technology.
- To develop regional and international dimensions of STI.

Data above is consistent with the distribution between the strategies, the first three strategies absorbed more than 88% of Colciencias' budget during the period 2001-2008; the training of highly qualified personnel received 27%, R&D capacities 35%, and innovation and productivity- related activities 26% (source: Colciencias internal records).

Monroy found that universities first and foremost interaction is with Colciencias (83% of the cases), and R&D centres' primary relation is with other R&D centres (33%), with Colciencias, universities, chambers of commerce, and other governmental agencies coming in second with an equal percentage (17%) (Monroy, 2004, p. 57).

As part of the process of social recognition given to the SNCyT, we observe that certain organizations have adopted several of the criteria and strategies promoted by Colciencias (e.g. CvLAC, GrupLAC, Publinindex). Some

universities -*Universidad de Antioquia*¹¹⁵ in particular- have experienced a positive change in their research performance, which is not due to Colciencias funding but to the legacy of its research and innovation policy. This university has assigned large amounts of money to fund top research groups. Others use Colciencias CvLAC as their curriculum vitae institutional database. Moreover, the ranking of research groups is considered today more important than project funding, thus recognizing that Colciencias' policies are appreciated as much as its financial contributions. Finally, Colciencias is just being able to fund a small percentage of the projects received, as the increase in its budget do not keep pace with the improvement of the national research capacities.

5.3.2 Government - Industry: the weak link

Based on the results of the third Innovation Survey for the manufacturing industry (2005-2006)¹¹⁶, the percentage of private firms using government innovation policy instruments to finance intramural innovation activities is very low, just 5.3% in 2005 and 4.3% in 2006, or 369 and 292 firms, respectively. These instruments are offered by several agencies, such as Colciencias, SENA, Proexport, and Fomipyme¹¹⁷. Looking at the grants, Colciencias is the major public funder for innovation, 63%; but in respect of the credits, it comes in third place with 7% of the money given. However, the proportion of grant moneys is much smaller than that given through credits, 11% in 2005 and 6.5% in 2006 of the total public funding for firms (DANE, et al., 2005).

Innovation activities are funded by Colciencias via two main policy instruments: grants for collaborative projects between firms and universities or

¹¹⁵ *Universidad de Antioquia* is the second largest public university in Colombia, located in Medellín, the capital city of the Antioquia department. This region comes second in every S&T indicator (expenditures, researchers, research groups, publications, etc.).

¹¹⁶ The national statistical agency is in charge of the innovation surveys in Colombia. It recently presented the first bulletin with the results of the third survey. The number of companies that answered the survey was 6,957, which is the universe of the annual manufacturing survey. The results bulletin can be downloaded from the DANE website.

¹¹⁷ Public promotion fund for micro, small and medium-sized enterprises.

R&D centres¹¹⁸, and credits with a subsidy. During the period 2000-2007 Colciencias allocated 17.4% of its money to firms, which executed 6.8% of total projects funded (OCyT, 2009a). In addition to these direct mechanisms for innovation promotion, Colombia has an R&D tax incentive for firms. The final amount of the discount is unclear, because once the CNCyT approves the project and the incentive, it is not known whether the company actually uses it or not. However, the number of firms that have applied and gotten approval during the period 2004-2008 were 414, which is a yearly average of 83 companies (OCyT, 2009c). Finally, there are other instruments oriented to the promotion of innovation, such as funding the mobility of personnel from academia to industry, support for the elaboration of business plans for start-ups, funding of technological international missions; but the amount of money allocated and the number of firms benefited, are marginal.

Looking at the data above, it seems that firms do not use public innovation-support instruments very much, even if Colciencias is well positioned among other agencies. In recent years, the government has set up other incentives for capital investment that seriously compete with R&D tax incentives and, therefore, the number of firms actually assisted by Colciencias has decreased. Following Monroy in her findings related to the interactions between the actors of the Colombian SNCTI, she found that companies' primary relation is with other firms (42.9%); and Colciencias was mentioned only by 4.8% of the people surveyed as the most important interaction (Monroy, 2004, p. 57).

In the panel with the productive sector, experts said that the SNCyT should be changed because entrepreneurs participate little. They also question the lack of representation of producer associations in the councils, as if Colciencias were adverse to establishing relationships with these agents. Several analysts have proposed that Colciencias should decentralize innovation-support instruments, giving the administration to producer associations or chambers of

¹¹⁸ It is important to mention that the money for collaborative projects is not received by firms, but by their counterpart, either a university or an R&D center. That is one of the reasons why, when looking at expenditures by performers, the productive sector receives so little, even if firms are the final beneficiaries.

commerce, which are closer to firms, a relationship that Colciencias has not been able to consolidate.

Historically Colciencias has had a closer relationship with the academic community. Even if innovation has been on its agenda for many years, and the Colombian NSI was formally created in 1995, entrepreneurs are not well represented in the SNCyT and its decision bodies; and the relationships established are weaker. The weakness of this relationship can be observed in many situations, for instance, the lost of track of entrepreneurs-councillors by Colciencias; the response rate of the entrepreneurs to the web survey conducted for this thesis (22% against 48% for researchers), and finally the low number of respondents from the Industry Programme¹¹⁹, 3 out of 74 (see table 11). Part of the problem with representation is that, in contrast with researchers, innovative entrepreneurs are not very visible to Colciencias, and generally for the country; there are no formal mechanisms to “advertise” their achievements. Moreover, the productive sector does not yet recognize Colciencias as a support agency and, importantly, very few of them apply for Colciencias funding, as they prefer to use their own money to finance innovation activities.

5.3.3 Academia - Industry: the weakest tie

Similarly to the lack of data to illustrate the intra-relationships in the productive sector, there is little information related to university-industry relations. Many actions by Colciencias have been undertaken to promote this interaction, such as the funding of collaborative projects, the funding of exchange of personnel (researchers doing internships at firms), support to regional university-industry-state committees or university technology transfer offices. Using again, data from the research project “Design and implementation of a characterization model for private research and technological development centres”, being developed by the OCyT, 35 of 100 private non-profit research and technological development centres state that one of their very significant clients are

¹¹⁹ These people could be either representatives of the research community or the private productive sector.

enterprises. As said above, Monroy found that companies primarily relation is with other firms, and universities come in the fourth place besides R&D centres (9.5%) (Monroy, 2004, p. 57). So there are many initiatives but no satisfactory results in terms of the number of firms actually collaborating with universities and R&D centres.

Arbelaez, Gómez and Tamayo conducted a cluster analysis to study the relationships between firms and universities with regard to innovation, based on the data of the second innovation survey, using a sample of 4,003 firms¹²⁰. The exercise produced three types of companies: isolated, trained and related, as they named them. The majority of firms (3,933, equivalent to 98%) are isolated, which means that they have little or none relationship with higher education institutions; this is the typical case of Colombian small and medium-sized enterprises. The second group, which is the most dynamic, is composed by the “trained” enterprises (58 firms equal to 1.45%), with strong linkages with universities that invest largely in training and conduct R&D projects; generally speaking are large companies, either local or multinational. The third group, which they call “related”, comprises 12 companies that do mainly technological development activities, have no specific size, and are primarily local companies (Arbelaez, Gómez, & Tamayo, 2009). This analysis shows that the number of Colombian firms that establish alliances and collaborations with academia are very few.

From the data presented above, it is difficult to establish, on the side of industry, whether the weaker tie is with government or with industry; the results are not conclusive, which is why I would recommend exploring this in more detail. Some could argue, that the interaction between industry and government is stronger due to the financial resources that mediate their relationship, but knowing the marginal number of firms that take advantage of government moneys for innovation activities, I will not completely buy that statement.

¹²⁰ The innovation survey is a census of all manufacturing firms (6,072) with more than 10 employees.

Certainly not using the knowledge produced by the research system put the productive sector at a disadvantage, debilitating the triangle of relationships.

In any case, based on the description of the intra and inter-relationships presented above one could characterize the Colombian SNCyT as a triangle in process of consolidation, where each vertex is getting more cohesive, and the articulation between them is growing. The degree of connectedness between vertices is not the same, there are some relationships stronger than others (government - academia). Meanwhile there is an actor that still is not fully convinced of the importance of STI, that is, the productive sector; therefore the interactions that it establishes either with government or academia are weak.

5.4 Colciencias' social capital

Based on the literature on innovation systems, these are composed by elements and relations among them. The Triple Helix and Sábato's Triangle models state that interactions among actors are what make them function. Therefore, the existence of a system can be observed if there are organizations (elements) and interactions among them working for a common purpose. In other words, if there is a network. In the development of those relationships, institutions and processes are recognized and either legitimized or not. In the Colombian case, it is important to clarify several issues regarding the existence of the SNCyT: i) What is the role of the legal framework?; ii) Has the SNCyT been legitimized by the actors?; iii) Are there one or two systems?

It is possible to explore the existence of social systems, in this case the Colombian Science, Technology, and Innovation System, according to the recognition granted by different actors. Experts consulted agree that laws and their regulatory decrees, gave form and power to Colombian S&T institutions, and created collegial spaces that gave more transparency to resource management. One of the persons interviewed said that what exists is a combination of a collegial system for decision-taking plus an entity that authorizes payments [a funding agency] (I-G). The issue here is legitimacy and

not legality, although a legal framework could contribute to the creation of institutions; these are produced by the construction and acceptance of social norms rather than formal rules. Colciencias is opened to other sectors and has gained greater status and importance within the Colombian State apparatus. Even if most interviewees acknowledge that Law 29 has been very important in building S&T institutions, as a law it could have remained on paper and not been implemented. But the law has been effective because of the recognition given to Colciencias, to its policies and strategies, and to the conviction that endogenous S&T capabilities are needed for national development. The building of Colombian S&T institutions has been a process of social construction, as Forero and Villaveces expressed in their analysis of the SNCyT:

Besides the creation of formal and informal institutions, the implementation of the system (SNCyT) was a social construction process of common understanding and collective purposes (Villaveces & Forero, 2007).

In the panel with regional representatives, the SNCyT was described as a set of social networks with the goals of scientific and technological development. They emphasize that it existed before the enactment of Law 29, as another expert says (I-J). It was argued that the system is generally seen from a hierarchical perspective, with actors, norms, agreements, laws, etc. and Colciencias as the leading entity. They claim that the system should be evaluated as a network or networks. In the same line of discussion, one of the experts explained (I-G) that it is possible to speak of two kinds of systems: one as a reality and the other as a legal framework, in his words:

“The system as a reality is a natural system, where interactions among the social actors are defined by time and space. Even though the natural system may be dysfunctional, it exists anyway. In this sense, the SNCyT exists, as does the National Innovation System. The other system exists as a legal framework, with some rules and a set of articulated policies. In Colombia, only the SNCyT has some principles, regulations, and some governing bodies which sustain it”.

In the interviews, people were asked if there are one or two systems in Colombia, taking into account that the National systems of S&T was created by law in 1990, and the National innovation system was created by the CNCyT in

1995. Most of the interviewees state that, in general, there is only one system in Colombia, the SNCyT, which comprises innovation activities, policies, instruments, and actors. However, some say that the creation of the national system of innovation fractured the SNCyT (I-C, I-N). The SNCyT has an image and defined institutions conferred by law and the academic community recognizes it. The main actors of the Colombian SNCyT -the universities, the R&D centres, the research groups, and the scientists - recognize Colciencias as the leader or authority on this subject, and as the national regulating, guiding, promoting, and funding entity of science and technology. Meanwhile, the primary actor of the NSI -companies- does not recognize Colciencias as the main entity. There is a significant institutional rupture in the NSI and no particular organization is recognized as the regulator or promoter, as many of the experts say (I-M, I-N). Alike one interviewee argues (I-J): “It would be ideal to keep both systems integrated under the same “*governance*”, but the ability of Colciencias to do so has been questioned”¹²¹.

Therefore, the existence the SNCyT is “certified” by the legal framework, the recognition granted by the actors, and the interactions that occur within it. In the words of a representative of one of the ministries: “The existence of the SNCyT requires the triadic combination of institutions, policy and investment”. The interactions in the SNCyT are triggered by Colciencias intervention, through the implementation of policies and the funding of STI projects, institutions, PhD programmes and training, and various dissemination activities. The legitimacy of Colciencias conferred by the actors of the SNCyT can be observed in many aspects: the adoption of policies, the articulation of organizations, and the coordination of financial resources.

Continuity in STI policies is one of the great successes mentioned by the experts, even if national science and technology policy is seen by some experts as a Colciencias and not a SNCyT policy (I-M). The broad policy guidelines and

¹²¹ The interviews were conducted before the new S&T law was enacted (Law 1286/2009). With the improvement of Colciencias’ status, and the incorporation of the word ‘innovation’ into the system’s title, now National System of Science, Technology and Innovation (SNCTI for its Spanish acronym), this situation has certainly been somewhat surmounted.

strategies have endured throughout the years. Also, the implementation of policies has had cumulative effects; building on what has already been produced. Policy instruments have not significantly changed, and no new instruments have been developed in recent years; the major changes occurred when the NSI was launched. Changes have occurred due to the different focuses of Colciencias administrations. Moreover, the acceptance from Colciencias to reassess programmes and instruments reveals a process of social recognition and institutional construction that is done on the basis of openness and credibility. When Colciencias is told or sees that a policy instrument is not working (e.g. ranking of research groups, indexation of academic Colombian journals), it begins a review process with the support of the communities, setting up expert committees.

For instance, support to research groups is considered a great success. Funding moved from individuals to groups and networks (relationships between groups and organizations), which has contributed to the strengthening of STI actors. The fact that universities, R&D centers and groups have agreed to the ranking process is another significant achievement; this was not an easy task due to the information demands and also because, initially, there was no inherent incentive to do so. The group ranking process contributed to giving greater international visibility and recognition to the national research groups, as experts have noted (I-F, I-N). Today, as one of the experts interviewed stated (I-N), the groups (and national academic journals) exhibit the ranking granted by Colciencias, using it as credential for competing in international calls for proposals.

Successful articulation of the SNCyT is seen in many fields, and has been demonstrated in many sections of this chapter, but let me recapitulate. The construction of the SNCyT can be observed in: i) the creation of institutions, understood here as norms and rules of the game that transcend Colciencias; ii) the legitimacy obtained by Colciencias as the national STI promoter entity, even if it is not the main funder; iii) the involvement of many public as well as private entities in the SNCyT; and, iv) the adoption of STI policies by the different actors,

regardless of the financial availability. The latter was highlighted by one of the interviewees (I-F), who says:

“The adoption of Colciencias’ policies by other entities, regardless of its financial aid, is a way of legitimizing its role in the SNCTI. Thus, Colciencias has gained legitimacy as a policymaker and not merely as a financial body. This has made it somewhat possible to overcome Colciencias’ budgetary crises. For example, the Ministry of Education needed a law to promote accreditation while Colciencias did not require such a law for the ranking of groups”.

With respect to funding, there are positive and negative issues, according to the experts consulted. On the negative side, the Law was insufficient because it did not secure stable resources for STI. The problem was the inability to implement the mandates of articles 4 and 7 of Law 29/1990¹²². There were no legal and political mechanisms to enforce them. Colciencias was not able to implement them, even with the support of the DNP; which made it impossible to articulate other public resources expended in S&T. One of the interviewees (I-K) says that Colciencias’ problem is not governance, but lack of financial resources, which the weaknesses, the partial successes and the failures depend on. It is clear that this problem is not only the responsibility of Colciencias, but is also due to the weakness of the CNCyT. Many of the experts believe that the National Council has been very weak, with little political power; the periods of time when it has been relatively important have been because of the person who held DNP Director General position.

All of these successes are partial for a fundamental reason. They are seen as unfinished works because there has been no clear political will, confirmed by an unstable flow of financial resources for the consistent implementation of the policies. In other words, it has not been feasible to guarantee a sustained effort due to the financial fluctuations. Consequently, it has not been possible to fulfill fixed goals or to make a long-term plan. Policy formulations without funding remain unenforceable. Many analysts consider that the levels of investment

¹²² These articles state that each year the CONPES should authorize S&T expenditures for every central governmental agency, which should be executed jointly with Colciencias. Besides, Colciencias should recommend (or approve) other public agency S&T investments, in order to rationalize expenditures in this area.

allocated to science and technology through Colciencias are meagre. Similarly, over a third of the people surveyed (38%) say that the lack of funding for STI activities is one of the most frustrating issues. In the panels, Colciencias was generally seen as an entity that has done many positive things with few resources, manages them well, thus there is justification for giving it more resources.

The positive aspect of funding -although it is due to a negative cause- is the growth in science and technology expenditures by the universities, due to the decrease in Colciencias resources. This has allowed continuing the dynamics of research and publication of many groups.

Taking into account the performance issue of social capital, the accomplishments explained above are certainly a measure of Colciencias social capital. The general hypothesis states that Sábato's Triangle model applied in Colombia has contributed to the cohesion of the SNCTI, building the social capital of Colciencias. The existence and performance dimensions of the system are given by the interactions between the actors, not just by drawing on what the law says, as one of the persons interviewed states (I-J). Colciencias' social capital is built and maintained through the relationships between the institute with other institutions (universities, firms, R&D centres, ministries, etc.) or with individuals, that is, the members of the various councils and the beneficiaries of the different programmes implemented by the agency. It appears that social capital has been created to the extent that Colciencias is open to various actors, allows them to participate, and provides spaces - physical and virtual - for their communication and interface. In particular, this was observed in relation to the PNCyT, as the axis of the SNCyT and Colciencias functioning.

In any case, Colciencias seems good at establishing relationships with formal organizations, which contributes to building social capital, but not as much with individuals. For instance, Colciencias does not monitor former councillors¹²³

¹²³ This situation was clear to me, when I was organizing the survey, when I could not track down all previous members of the councils because Colciencias managers did not have their contact information. This is reflected in that most of the respondents are current councillors (57%), 24%

or beneficiaries, such as people that have won Colciencias scholarships, thus losing or destroying part of its social network. Colciencias convenes universities and R&D centres to discuss changes in the implementation process of policies (e.g. changes to ScienTI or Publindex), or to present national S&T policy, but councillors, as such, are not invited to those meetings. To my knowledge few meetings have been held with council members to discuss policy. Councillors point to that problem, stating that they are usually not convoked by Colciencias to discuss policy issues.

Colciencias acts as the manager of the hierarchical network that is the SNCyT as a whole, composed by various networks which are the CPNCyT. In this type of networks, success depends on outsiders (councillors) rather than on insiders (Colciencias' officials). Therefore, the councillors are key enablers for the construction of social capital around Colciencias and the SNCyT. In this sense, if we look at the SNCyT as a whole, and since it is an open system, it is more difficult to observe social capital building. However, the CPNCyT are closed networks, considering that their composition and functioning are defined by law and Colciencias' rules. The closeness of the network is what allows its members to build social capital and benefit from their position. Burt says that participation in, and control of, information diffusion are important aspects of social capital, as well as brokerage opportunities (Burt, 2000, p. 353). Even if councillors do not control information diffusion, they have privileged and early access to that information, which gives them certain advantage.

According to Lin (2001), four elements make social capital work: information, influence, social credentials and reinforcement. Based on social capital literature, we should ask: What are the resources embedded in the social network, in this particular case the CPNCyT, from which social capital can be built? The answer is information and power or influence, exerted via the approval

were active during the period 2001-2005, 14% from 1996-2000, and 5% from 1991-1995. Certainly most of the councillors identified are from recent periods, and when I contacted former councillors, many said that they had lost contact with Colciencias and were not very interested in participating. I had to make explicit that I wanted their opinion, even if they were no longer involved with Colciencias or the SNCTI.

of project funding. These are accessible to every member of the council and for the most part appropriated collectively, rather than individually. This is because the benefits they perceive from being councillors are to exert influence in the SNCyT as a whole, to diffuse information (for the benefit of many), and the use they give to that information is to influence their academic discipline. If councillors do appropriate resources individually, they do not recognize it.

6 CONCLUSIONS

This concluding chapter is organized in three main sections: overall results, policy recommendations, and a future research agenda. The findings will be organized around three theories and approaches which I considered key to understanding the governance of the system: Triple Helix, Principal-Agent, and Social Capital; starting with making the case of the existence of the Colombian SNCTI and the importance of its governance mechanism: **Sábato's Triangle**. Considering that this latter model is normative, I will expose the contributions, effects and impacts that the organizational arrangement has had on building the S&T system, and the mechanisms used to make it functional.

6.1 Main results

For a system to exist, it requires the triadic combination of institutions, policy and investment, as one the people interviewed stated. Therefore, the construction of the SNCTI has been observed and measured through different variables in each dimension, as follows:

- Institutions: participation of organizations and recognition, tripartite interactions, and P-A relationships.
- Policy: processes of formulation, negotiation, implementation, adoption and evaluation of policies, programmes, etc.
- Investment: Colciencias' leveraging capacity, and articulation of other public funds.

Generally speaking, governance involves the interaction between formal and civil society institutions. The governance of an STI system involves interaction between formal organizations (research councils, government agencies, companies, universities, R&D centres, etc.) and researchers, entrepreneurs, and society in general. The governance of STI institutions in Colombia was certainly affected by law 29, which created the SNCyT as an

open, participatory system, based on merit. The implementation of the law produced: i) the framework for the development of STI in Colombia; ii) the development of new policy instruments; and, iii) the formalization and strengthening of an institution that is socially recognized and legitimized, which is the SNCyT.

Based on systems' literature, these consist of elements and the relations among them. The Triple Helix and Sábato's Triangle models state that interactions among actors are what make them function. Therefore, the existence of a system is confirmed if organizations and individuals interact purposely, in other words, if there is a network. In the development of these relationships, institutions and practices are recognized and legitimized, or not. Sábato & Botana proposed a series of inter-relationships between the vertices, which after the analysis of the Colombian case could be complemented as shown in the table below.

Table 17: Categories for the analysis of inter-relationships – Sábato's Triangle

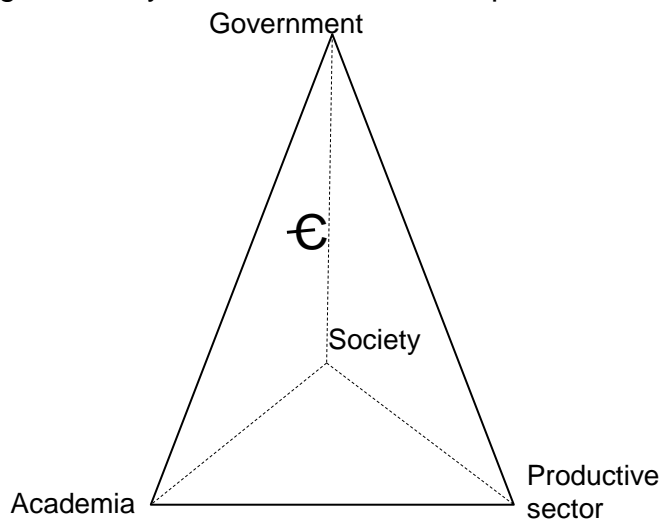
<i>Inter-relationships</i>	<i>Sábato & Botana</i>	<i>Newcategories based on the case study</i>
Government - Academia	Resource allocation Demand of knowledge and technology	Funding (transfer of resources) Transfer of tasks (P-A delegation) Policies Application of research results in the design of policies
Industry - Academia	Interchange of personnel	Demand of knowledge Sharing of ideas Interchange of personnel Alliances
Industry-Government	Both, to make use of existing knowledge produced by academia	Funding Policies

Source: Prepared by the author.

Few analysts, or none at all, would disagree that tripartite relationships are not essential for defining research and innovation strategies, but these interactions are neither easy to achieve nor developed automatically; actions

need to be taken to facilitate them. Some scholars and activists are arguing that a fourth sector should be included: civil society (see for instance Guston, 2004; Guston & Sarewitz, 2002; Hennen, 1999; Jasanoff, 2004). Certainly the incorporation of the civil society is key for the democratization of STI policy, but this is simpler to say than to achieve. In this sense, I am proposing a new representation of these interactions, including the fourth sector, and putting Colciencias in a different position, as neither part of the scientific and education infrastructures, as Sábato and Botana proposed, nor in the government vertex, but in the middle of a pyramid, articulating and facilitating the interactions of all sectors. In the Colombian case, Colciencias is the boundary organization facilitating the relationships, but in other countries could be S&T ministries, agencies or councils.

Figure 18: Pyramid of STI relationships



Source: Prepared by the author. Note: €: Colciencias.

The inclusion of society in these models, as either a fourth vertex, helix or pillar, challenges us, first of all, to establish when in the processes of formulation, negotiation or implementation of policies must society intervene and, secondly, to propose innovative forms for their representation in this pyramidal relationship model.

If we look at the first two elements mentioned above, institutions and policies, the initial impression is that the Colombian SNCyT is successful; but

when a careful observer looks at the moneys available for supporting all this activity and sees so little, he/she could question the results obtained. Therefore, even if the size and instability of Colciencias' budget has been an obstacle to the improvement of local capabilities (the STI community is still small, with meagre results in terms of publications, patents, innovations, etc.); it has favoured the recognition of Colciencias not as just a funder, but also as a policy-maker. As explained above, some of its policies are much more important for the promotion of STI activities than the funding. In this sense, the agency dedicates more time to formulation and negotiation of policies rather than to the allocation of its budget. The latter function could be delegated to an intermediary.

I found that the **Triple Helix circulation** (diagrams 6 and 7) provides a practical framework i) to characterize the relationships among the various actors of any research and innovation system; ii) to track information flows (following people, ideas, and innovation or policies); and, iii) to identify the roles of the main actors, breaking the usual institutional view point. With respect to the circulation of staff, in the Colombian SNCTI there are many possibilities, although alternation and dual-life are the most frequent. The revolving door or alternation is very common, both from the industry and the academia to the government. The case of Colciencias is very interesting because there are university professors and researchers on commission in the agency in leadership positions, and they usually continue to teach.

With respect to communities of practice, the councillors comprise a group of experts who have a common interest in an S&T field or area; and the CPNCyT as such is organized, regulated and framed by the SNCTI and Colciencias. In this sense, the communication between them seems to be facilitated; it was interesting to observe the resemblance in the answers they provided to the open questions; even the expressions were similar. In this type of communities is usual to find common codes of communication.

The councils of the Colombian SNCTI can undoubtedly be understood as policy-networks, considered as either a form of governance or an interest

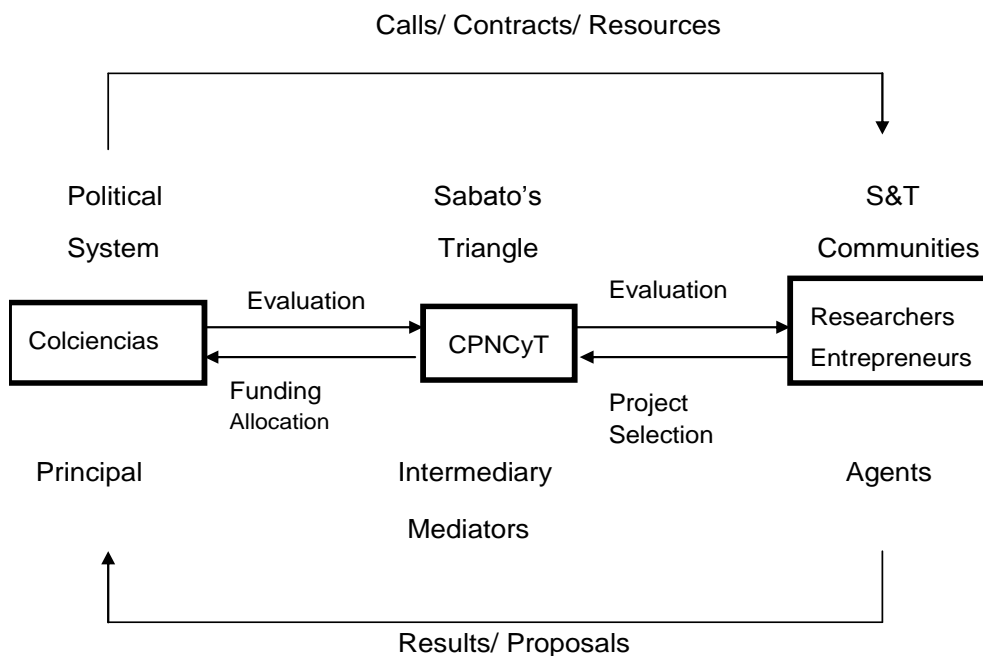
intermediation mechanism. In the case of the CPNCyT, on the one hand, policy formulation is one of the council functions regardless of how effectively it is performing it; in addition, all other functions related to the management of STI activities as such (i.e. evaluation, selection and approval of projects) are also key to the governance of science. On the other hand, regarding interest intermediation, there are unquestionably many interests (public and private) that intervene in the council, which by default produce tensions and conflicts, as the objectives and goals pursued are different and sometimes divergent. Clearly if Colciencias recognizes and accepts the different interest groups present in the councils, conflict could be managed.

One of the persons interviewed states that “the SNCyT has functioned by inertia, thanks to Colciencias”. On the contrary, I think the SNCyT functions despite Colciencias. If we look at the SNCyT and the tripartite relationships at the system’s level, certainly Colciencias has been crucial for making those interactions happen. But going to the level of the programmatic councils, and considering the PNCyT the axis of the SNCyT and Colciencias, the picture changes. In this case, I think that Colciencias has not favoured the development of the CPNCyT. Social capital has been built because of the councillors and their devotion, altruism, and desire to contribute to national scientific and technological development. Councillors know their role and the faculties and functions mandated by the law, although Colciencias does not allow them perform all of them. In this sense, they are limited by Colciencias, which provides the norms and rules, and determines when and for what purposes they will meet. In this sense, the dealings between Colciencias and the CPNCyT are flawed, since it seems that Colciencias does not really know what it wants the councils to do.

In respect of policies, the key variables defined were trust and transparency, now I will add accountability, all of which are elements of the legitimate processes of policy-making, achieved in the different phases: formulation, negotiation, implementation and evaluation. These elements are basic for the interactions between the groups of actors, without them the relationships could not be properly developed.

As Braun and Guston (2003) say, **principal-agent** theory provides a useful insight into the relationships between government and the scientific community, and the third party or intermediary that many identify with research or granting councils. I think that the P-A configuration of the Colombian SNCTI is quite balanced (drawing on Figure 9a), where scientists play an important role, but the principal (Colciencias) in reality maintains the control over the resources (financial and human) and does not transfer them to the intermediary (CPNCyT). Even if it is a balanced configuration, councillors do not question Colciencias' rules and norms; they just criticize the operational aspects. In this sense, councillors sometimes feel that the project approval process within the councils is a "ritual passage", like one more step that they feel instrumental, but not essential. Following this idea, one could represent the P-A model with three actors, with the CPNCyT as intermediary agents, but the direct relationship being between Colciencias and the STI communities, or final beneficiaries of Colciencias' action (see figure below).

Figure 19: The triadic structure of the P-A model in Colombia



Source: Prepared by the author, based on Braun, 1993.

The SNCTI is a social organization that incorporates both formal organizations and informal institutions, all of which perform articulation, coordination and management functions at different levels and exerting different power. The CPNCyT can be seen both as formal or informal organizations. From a formal point of view, they are included in the Colombian SNCTI organizational chart and they have clear tasks (mandated by law). But in practice, they look like informal organizations, since councillors' actions are not mediated by contracts; there is no job description; and no associated payments. Even if there are rules and norms, they behave like a **social network** where trust and transparency are essential, and legitimize their roles. In this sense, the CPNCyT can be defined as "spaces for consensus building", using the expression formulated by Etzkowitz and Ranga. According to these authors, these spaces are not necessarily places, meaning that they do not have to be physical; they are understood as instruments for communication and coordination.

As said before, **social capital** is understood as an outcome of social networks, that is the result of the interaction of actors. In the CPNCyT, the resources embedded in the network, and used by the councillors, are information and power or influence, the latter exerted via the approval of project funding. These resources are accessible to every member of the council, and are appropriated collectively for the most part, rather than individually. If councillors benefit personally from being part of the council, they do not recognize it. The other two probable gains -certify individual's social credentials and reinforce identity and recognition- were not considered by the councillors as benefits they receive from being part of the SNCyT.

The cohesion of the SNCTI could also be observed in the speech similarities and the agreements and disagreements. The discourse of the different councillors is impressively alike. The majority of the experts coincided with regard to most of the policy successes and failures and the notable implementation of the system. With respect to the performance of the national, programmatic and regional councils, the disagreements are between the councillors and experts consulted. Expectations, perceptions and reality seem

not to converge. Colciencias' officials have high expectations about the councils' performance, not fulfilled. The councillors think that they are not doing what they are suppose to do, and claim for more time, space and money. And reality shows a SNCyT that works, Colciencias' action is legitimated by the collegial spaces created, which give more transparency and accountability to the management of resources, and a democratic flavour is introduced because of the tripartite participation –even if it is not a proper representative scheme. It is certainly with respect to policies that Colciencias is legitimized, in the adoption by various actors of different initiatives, such as the group ranking process.

Finally, the diverse theories and approaches used in this thesis have proven to be useful analytical frameworks to explain the governance of research and innovation systems, and the underlying communication processes that occur between the various actors participating in the systems.

6.2 Policy recommendations

- Colciencias and the council members should recognize the existence of interest groups inside the councils, and deal with the conflicts and tensions inherent to these relationships.
- Increase and improve the participation and representation in the councils of the private productive sector.
- Design mechanisms to make innovative entrepreneurs more visible to Colciencias, in particular, and to society, in general, either by using existing information, such as the national innovation prize or the innovation surveys, or looking for new sources of information.
- With respect to Colciencias' roles as a funding and policy-making agency, the problem is that it does not have enough resources to do both equally well and most of its resources are dedicated to executing its own budget, disregarding other very important functions. Therefore, the agency should focus on the formulation and negotiation of policies rather than the allocation of its budget, considering that the impact it could have via the

adoption of policies by various actors of the SNCTI and the harmonization of promotion and funding criteria are much more important than financing. The funding function could be fully delegated in an intermediary, providing clear rules and criteria.

- For the sake of building a stronger SNCTI, and more effective relationships between Colciencias and the CPNCyT, the functions of the councils should be clarified and their scope of action clearly defined. As said before, the councils are adequate mechanisms for the governance of STI, so the government should make a better use of them to formulate effective policies, having at hand high level advisors, strategic partners and enablers of social capital.
- Colciencias, as the head of the SNCTI, should concentrate on gathering and analysing information about what the agents need, in order to formulate better and more aligned policies, and defining which institutions are going to implement them.
- Observing the situation of university-industry relationships in Colombia, it seems that the mechanisms, the institutional arrangements, the policies, and the intellectual property regime exist to favour the collaboration between universities and companies, but these are still quite infrequent. Aware of the difficulties of building these relationships, perhaps the country needs to make greater efforts to train and prepare innovation managers, technology brokers, and technology transfer officers, and other individuals who can help to build these connections.

6.3 A research agenda

- Based on the data already collected, in particular the councillors survey, I would like to analyze if there are different perceptions and roles between researchers-councillors and entrepreneurs-councillors, and between men and women, trying to identify blocks of actors, following Conway's proposal of relational configurations in network analysis.

- Conduct a proper social network analysis, using mathematical instruments, to map the connections between councils' members and Colciencias' directors and managers.
- Carry out an analysis similar to the one made in this thesis, of the regional councils (i.e. Codecyt). However, I know *a priori* that tracking the members will be difficult, since these people change position very frequently, and we already know that Colciencias does not keep records of councils' members.
- Develop a characterization of Sábato's Triangles relationships for specific sectors or programmes; analysis that will allow us to see more clearly how the actors interact to define STI strategies in a particular field.
- Evaluate the convenience of having policy-making and funding within the same agency, especially now that Colciencias has been assigned more responsibilities and functions and has a higher status within the Colombian state apparatus.
- Improve the empirical indicators of governance, moving from indicators based on perceptions to indicators that specifically measure the capacities of particular institutions and their relationships.
- With the data presented above it is difficult to say from the perspective of industry which is the weaker link, if with government or academia; results are not conclusive, thus I would like to explore this issue in more detail.
- With respect to studies based on the systems of innovation approach, more emphasis should be placed on interactions, flow of information and knowledge, on communicative and social aspects, not the institution checklist. I would like to undertake a comparative study of innovation systems, preferable regional, to analyze them from a social and communication view points.

APPENDICES

Appendix A: In-depth interview guide

a) English version

1. Do you think that we have two different and autonomous systems in Colombia: the National Science and Technology System and the National Innovation System?
 - a. What were the contributing factors of this fracture?
 - b. Do you think that the separation of science-oriented S&T programs from innovation-oriented S&T programs contributed to the change in dynamics of the research groups?
2. In your opinion what are the three main accomplishments related to science, technology and innovation (STI) policy in the past 15 years?
3. What have been the major failures and obstacles for its implementation?
4. Do you consider that in the last fifteen years Colombia has experienced fundamental changes in STI policy?
 - a. If so, how have they affected the structure and the organization of the SNCyT?
5. What were the achievements of the National S&T Law (Law 29/1990) and the decrees? What were the mistakes?
 - a. Do you think that the country should follow the regulation of the law?
 - b. Do you consider that the legal structure has changed since 1991?
 - c. Do you consider it necessary to issue a new S&T law?
6. How would you qualify the operation of the National S&T system and its coordination bodies (national, programmatic, and regional or departmental councils)?
 - a. Do you consider the creation of an S&T Ministry as necessary and convenient?
7. How would you qualify the operation of the National Innovation System?
8. Do you believe that the main problem is related to (formal) organizations, (informal) institutions, budgetary issues, political will, or other?
9. In relation to financing issues, what are the lessons learned? What were the correct and incorrect choices?

10. In your opinion, what are the alternatives to maintaining a regular and sufficient budget for STI activities?
- Do you consider it necessary to obtain an international loan for financing of system?

b) Spanish version

- ¿Considera usted que Colombia tiene dos sistemas diferentes independientes y autónomos: el SNCyT y el SNI?
 - Si sí, ¿a qué atribuye usted la fractura del SNCyT?
 - ¿Considera usted que la separación entre programas orientados a la investigación y la innovación ha cambiado las dinámicas de algunos grupos de investigación?
- ¿En su opinión cuáles son los tres mayores logros en materia de política en CTI en los últimos 15 años?
- ¿Y cuáles han sido los mayores fracasos y obstáculos para su implementación?
- ¿Considera ustedes que en los últimos 15 años ha habido cambios fundamentales o sustanciales de la política de CTI?
 - Si sí, ¿cómo ha afectado esto la estructura y organización del SNCTI?
- ¿Cuáles son los grandes aciertos de la Ley 29 de 1990 (ley de CyT) y sus decretos reglamentarios? ¿Cuáles los desaciertos?
 - ¿Considera que se debe continuar la reglamentación de la Ley 29?
 - ¿Considera que el marco legal del SNCyT se ha transformado desde 1991?
 - ¿Considera necesario la expedición de una nueva ley de CyT?
- ¿Cómo calificaría usted la operatividad del SNCyT, y la influencia que han tenido sus diferentes instancias (consejo nacional, consejos de programa, comisiones regionales/consejos departamentales.)
 - ¿Considera usted conveniente y necesario la creación de un Ministerio de CTI?
- ¿Cómo calificaría usted la operatividad del SNI?
- ¿Considera usted que el problema principal del sistema es de instituciones o institucionalidad, presupuesto, voluntad política, u otro problema?

9. En cuanto a los asuntos de financiamiento de la CTI ¿cuáles son las lecciones aprendidas, los aciertos y desaciertos?
10. En su opinión ¿cuáles son las alternativas para mantener un presupuesto regular y suficiente para la CTI?
 - a) ¿Considera necesario contar con un crédito externo para el financiamiento del SNCyT? Porqué?

Appendix B: Councillor web survey

a) English version

1. Name
2. Sex: Male/Female
3. How old are you?
 - a. Less than 35 years old
 - b. 35 - 45 years old
 - c. 46 – 55 years old
 - d. 56 – 65 years old
 - e. More than 66 years old
4. Department of residence
5. Which council do you belong to?
 - a. Basic sciences
 - b. Social sciences and humanities
 - c. Scientific studies on education
 - d. Health
 - e. Marine sciences
 - f. Environment
 - g. Industry
 - h. Biotechnology
 - i. Agriculture
 - j. Energy and mining
 - k. Electronics, telecommunications and informatics
6. Have you participated in the council as:
 - a. Entrepreneur
 - b. Researcher
7. How many years have you belonged to the council?
 - a. Less than a year
 - b. 1-2 years
 - c. 2-4 years
 - d. More than 4 years
8. Have you been re-elected? Yes or No
9. What benefits do you receive or perceive as a councillor?
 - a. Acquire and transmit valuable information

- b. Exert influence on agents from the SNCTI
- c. Exert influence in the S&T national development
- d. Certify social credentials
- e. Reinforce identity and recognition
- f. Know more about the SNCTI and research and innovation policy.
- g. Represent your institution of research community
- h. Help to maintain funding equilibrium for your institutions, region or academic discipline.

10. What is most gratifying for you as a councillor? Explain.

11. What is the most frustrating? Explain.

12. With which groups do you share the information that you receive in the meetings of the council? (you may choose two options)

- a. You keep it to yourself
- b. You share it with colleagues within your organization
- c. You share it with colleagues outside your organization
- d. You share it with your family
- e. You share it with your bosses
- f. You share it with your students or assistants.

13. How do you use the information you receive at the council sessions? (choose two options)

- a. Influence the strengthening of your academic discipline.
- b. Formulate and present research or innovation projects.
- c. Formulate institutional projects, plans or strategies.
- d. You apply or use it for your personal benefit.

14. How would you describe your participation in the council? (you may choose two options)

- a. Active hearing
- b. Passive hearing
- c. Participation in discussions
- d. Non-participatory
- e. Discursive, digressive
- f. Other. Explain

15. How would you describe your role in the council? (you may choose two options)

- a. Proposer: provides new elements for discussion
- b. Facilitator: guides the discussion
- c. Practical: grounds the discussion
- d. Catalyst: contributes to decision-taking
- e. Mediator: contributes to conflict solving
- f. Other. Explain

16. What would you highlight as the major difficulty for the development of your role as a councillor?
17. What are the key real functions of the programmatic councils? (choose the two most important)
 - a. To approve or recommend project funding
 - b. To define funding priorities
 - c. To define main research lines or topics of the Programme
 - d. To formulate research and innovation policy for the Programme
 - e. To coordinate S&T policies with other policies
 - f. To share information between diverse actors of the SNCTI
 - g. To discuss national priorities
18. What would you highlight as the main contribution of the Council for the development of the Programme?
19. Do you think that the functions of the programmatic councils should be modified? If yes, why? Explain.
20. Do you believe that the composition of the programmatic councils should be modified? If yes, who should leave, who should enter?
21. Do you consider that the mechanisms for councillor election are correct?
Yes, no
22. If not, do you propose:
 - a. Election within your organization
 - b. Formal representation of your institution
 - c. Elected directly by the Colciencias Director.
 - d. Other. Explain.

b) Spanish version

1. Validación usuario
2. Sexo
 - a. Masculino
 - b. Femenino
3. Edad
 - a. Menos de 35 años
 - b. 36 - 45 años
 - c. 46 – 55 años
 - d. 56 – 65 años

- e. Más de 65
4. Departamento en que reside.
 5. Consejo al que pertenece (o perteneció)
 - a. Ciencias básicas
 - b. Ciencias sociales y humanas
 - c. Estudios científicos de la educación
 - d. Salud
 - e. Ciencias del mar
 - f. Medio ambiente y hábitat
 - g. Agricultura
 - h. Biotecnología
 - i. Desarrollo tecnológico industrial y calidad
 - j. Energía y minería
 - k. Electrónica, telecomunicaciones e informática
 6. Es (fue) miembro del Consejo en calidad de:
 - a. Empresario
 - b. Investigador
 7. ¿Por cuánto tiempo ha pertenecido (o perteneció) al consejo?
 - a. Menos de 1 año
 - b. Entre 1 y 2 años
 - c. Entre 2 y 4 años
 - d. Más de 4 años
 8. En qué periodo ha sido (o fue) miembro del consejo:
 - a. 1991 - 1995
 - b. 1996 - 2000
 - c. 2001 – 2005
 - d. 2006 – 2010
 9. ¿Fue re-elegido? Si, no
 10. ¿Qué beneficios recibe o percibe usted al ser consejero de un PNCyT (seleccione las 3 más importantes))
 - a. Recibir y transmitir información valiosa
 - b. Ejercer influencia sobre agentes del SNCTI
 - c. Influir en el desarrollo de la CyT del país
 - d. Certificar sus credenciales
 - e. Reforzar su identidad y reconocimiento
 11. ¿Qué ha sido lo más gratificante para usted como consejero?
 12. ¿Qué ha sido lo más frustrante?

13. ¿Qué hace con la información que recibe en las reuniones del consejo? (seleccione las tres más importantes, siendo 1 la más importante)
- a. La guarda para usted
 - b. La comparte con sus colegas al interior de su organización
 - c. La comparte con sus colegas fuera de su organización
 - d. La comparte con su familia
 - e. La comparte con sus jefes
 - f. La comparte con sus estudiantes y asistentes
 - g. Se le olvida que han discutido
 - h. Le sirve para escribir y formular proyectos, políticas, estrategias, planes institucionales, etc.
 - i. Le da ideas que aplica en beneficio personal o profesional
14. ¿Cómo describe su carácter o posición en el consejo? (seleccione una opción)
- a. Escucha activa
 - b. Escucha pasiva
 - c. Participativo
 - d. No participativo
 - e. Discursivo
 - f. Otra. Explique
15. ¿Cómo describe su papel en el consejo? (seleccione una opción)
- a. Par experto
 - b. Facilita la discusión
 - c. Práctico, aterriza la discusión
 - d. Catalizador, contribuye a la toma de decisiones
 - e. Contribuye a la resolución de conflictos
 - f. Otra. Explique
16. ¿Qué destacaría como la mayor dificultad para el desempeño de la labor como consejero?
17. ¿Cuáles son las funciones clave del Consejo del PNCyT? (seleccione las tres más importantes, siendo 1 la más importante)
- a. Aprobar/recomendar financiamiento de proyectos de investigación o innovación
 - b. Definir prioridades de financiamiento
 - c. Definir las líneas de investigación principales del Programa
 - d. Formular política de investigación e innovación para el Programa
 - e. Coordinar políticas de CTI y políticas sectoriales
 - f. Compartir información entre diversos actores del SNCTI
 - g. Discutir sobre las prioridades “país”

18. ¿Qué destacaría como el principal aporte del Consejo al desarrollo del PNCyT?
19. ¿Considera usted que las funciones de los Consejos de los PNCyT deben ser modificadas? Por qué?
20. ¿Considera usted que la composición del Consejo debe ser modificada? Si si, qué perfiles o cargos deben salir y cuáles deben entrar?
21. ¿Considera usted que los mecanismos de designación de los consejeros deben cambiar? Si o no
22. Si si, ¿cuáles deben ser los mecanismos de designación?
 - a. Elección democrática
 - b. En representación formal de academias de ciencias, ONG o gremios de la producción
 - c. Elegidos directamente por el Director General de Colciencias
 - d. Otro. Explique

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