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Organizational Ecosystems: Interaction and Alignment Towards Innovation

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1. Introduction

The decrease in the time required for the introduction of innovations in the marketplace, the increasing technological complexity of these innovations, the requirement of diverse competencies for its development and the high costs implied in the introduction of new products and processes in the marketplace have made unviable the single development of innovations in any public or private organization individually, especially those small and medium-sized (De Pellegrin *et al* 2007). Because of this, multiorganizational arrangements have often had the role of joining competences and resources of heterogeneous organizations aiming to develop conjointly costly and complex innovations. In most cases, the organization of these arrangements are integrated to sectoral development policies headed off by State entities, who consider the introduction of innovations as a safe path to competitive insertion of regional and national industries in the markets of high added value products and with the potential of generating high-level jobs.

However, the constitution of these arrangements is not a magic formula that assures the success of innovative efforts. Firstly, in order to meet the goal of joining the different skills required for developing complex innovations, the multiorganizational arrangements must be composed of heterogeneous institutions. These heterogeneous kinds of arrangements generate very frequently communication and integration difficulties,[1] whose overcoming depends on effective mechanisms for coordination. Secondly, often such arrangements are limited in terms of participating institutions, fact that limits the possibilities of induction of a complete technological transfer project, generator of innovation, for which the participation of a wide range of organizations that fulfill specific functions in the process

[1]A very commonly cited example of this problem is the integration between universities and private companies, made difficult by factors such as the definition of intellectual property rights, lacks of communication, inadequacy of human resources, funding inconstancy, sociocultural conflicts and differences in acceptable deadlines in project execution (Rapini, 2007). In Brazil, such difficulties reflect in a science and technology system with respectable performance in scientific production, however generating few innovations in private companies (Velho, 2004; Lotufo, 2009).

is essential (such as technological, regulatory and marketing functions). In most of the cases,[2] to complete an innovative process, the participation of private sector organizations, research institutes and government agencies are required.These institutions as a whole are the constituting elements of organizational ecosystems related to an industry or a technology. In view of this problem, this chapters goal is to describe the Brazilian National Institute of Science and Technology in Micro and Nanoelectonic Systems (INCT/NAMITEC), showing its main indicators and forms of network coordination, focusing on the activities of the Coordination of Knowledge Transfer to the Productive Sector of INCT/NAMITEC (Coordination A.7.). Hereby are also presented the main advances and problems in terms of multiorganizational cooperation and transference of technological knowledge in the area of microelectronics to the productive sector and to society.

The remainder of this chapter is organized as follows. Section 2 presents selected approaches regarding concepts of multiorganizational arrangements towards innovation: techno-economic networks, innovation systems, triple helices and organizational ecosystems. Section 3 presents INCT/NAMITEC, emphasizing its main management instruments, results and limitations towards technological transfer promotion. Section 3 ends with a proposal of a multiorganizational arrangement management model based on the concept of organizational ecosystems developed within the activities of Coordination A.7. Section 4 enriches the previous discussion with the participatory approach to organizational ecosystems. And finally, section 5 presents the findings of the chapter: an efficient management of multiorganizational arrangements towards innovation must promote the integration of several organizations that compose the organizational ecosystem and that carry out essential functions in the innovative process.

2. Multiorganizational arrangements to technological and innovation transfer: Techno-economic networks, innovation systems, triple helices and organizational ecosystems

Several denominations are given to multiorganizational arrangements directed to technological transfer for innovation. Amongst the most utilized ones, here will be described the concepts of techno-economic networks (Callon, 1992), national, local and sectorial systems of innovation (Nelson, 1993; Cassiolato e Lastres, 2000; Malerba, 2002; Hekkert *et al*, 2008) and Triple Helix (Leydesdorf and Etzkowitz, 1996; Etkowitz e Leydesdorf, 2000). These concepts define arrangements deliberately organized to join the efforts of the public and private organizations, aiming towards the development of one or more innovations. They frequently inspire innovation policies based on the organization and coordination of multiorganizational arrangements**:**

"In several countries, the technological policies have emphasized cooperation programs between the public and private sectors to stimulate and support the company's efforts, reduce risks and maximize the results of the scientific training built locally. These efforts, besides

[2]The nature of the institutions involved in the innovative process (ecosystem) depends on the particular characteristics of the artifacts and institutions involved, such as sector, localization, technologic complexity, ethical and legal aspects, among others.

encouraging partnerships between universities, research institutes and companies, are also oriented towards a larger interaction between the companies themselves, either as research "cooperation networks", shared centers, common infrastructure, or by mean of explicit politics of support in arrangements and local systems of innovation." (Lotufo, 2009: 42).

The network concept is utilized in various fields of science to describe complex systems constituted of diverse components (Börzel, 1997). In social sciences, stand out the studies about industrial networks, business management networks and public policies networks. In the field of science, technology and innovation studies, Börzel (1997) considers seminal Michael Callon's article, *The Sociology of an Actor Network; the Case of the Electric Vehicle*, published in the book *Mapping the Dynamics of Science and Technology: Sociology of Science in the Real World.*

In a posterior article, Callon (1992) introduces the concept of techno-economic network, describing the components of the technological and innovation transfer networks as being formed by several heterogeneous actors belonging to three poles: a scientific pole, producer of knowledge; a technological pole, oriented towards application of knowledge; a market pole (companies and customers), where the innovation spreading is accomplished . Between these poles are intermediaries that mediate the interactions between the actors, such as scientific and technological documents (articles, patents), competencies and capabilities (that circulate, for example, through courses and professional mobility), financial resources (funding, sales), as well as artifacts (scientific and technological equipment). Callon (1995) proposes a typification that differentiates convergent and divergent networks: a convergent network is one where the actors present a consensus on what actions should take place (which technology to adopt, for example); on the other hand, in a divergent network there is no established consensus towards what actions should take place, coexisting different opportunities of action, fact that makes it harder to align the actors. In general terms, the convergent networks are built around technologies with well stable and consolidated trajectories; divergent networks are typically those around new technologies, technologies upon which rest great uncertainties regarding the trajectory to follow, thus requiring a more intense negotiation process between the actors, based on the exchange of intermediaries, therefore turning the technological transfer process into a complex and uncertain one.

Corallo and Protopapa (2007) refer the concept of innovation networks to the studies of Manuel Castells, organizer of the book *The Rise of the Network Society*, of 1996. Castells considers the private company the central *locus* of the transfer of technology on innovation networks. These networks are nothing more than a form of organization adequate to environments of high degrees of uncertainty, where it is necessary to change from a vertical governance structure (concentrated on individual companies) to a horizontal structure (dispersed amongst diverse organizations). This new form of governance, facilitated by the technologies of digital communications, has as its main characteristics the exploration of complementarities and collaboration between organizations, pointing organizations towards processes of co-evolution nurtured by the exchange of knowledge and initiated by a common characteristic (geographical, institutional, ideological or technological) that approaches organizations around common interests.

De Pellegrin *et al* (2007) proposes a network management model named Rede de Inovação Horizontal Induzida (Horizontally Induced Innovation Network) (RIHI). In a RIHI, the Government and/or a group of companies[3] develops action plans to enhance or develop the cooperation between organizations in a sector, aiming their convergence in the innovation process. To reach this objective, it is necessary to create an organization whose objectives and structure are decided by the participating actors, including a coordination center that harmonizes the network's member's different objectives, keeping in sight the companies objectives, considered by the actors the *locus* of innovation. It is up to this coordination center to recruit the members of the network, articulate the cooperation and technological transfer relations (utilizing, for example, calls for cooperative research projects between universities and companies), organizing information of interest (such as market prospection), acting on environmental factors (promoting actions focused on specific markets), creating learning mechanisms (like courses and trainings) and acting along with supporting institutions (facilitating technological service provision, such as certification/accreditation, for example). This way it is up to the network coordination center to reduce the risk of companies engaging in a collaborative project of technological innovation through prospection of opportunities and promotion of collaboration between companies, as well as between companies and other institutions.

The concept of Innovation Systems,[4] according to Edquist (2001), was introduced by three authors: Christopher Freeman in 1987, in the book *Technology Policy and Economic Performance: Lessons from Japan*; Bengt-Aake Lundvall, who in 1992 organized the book *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*; and Richard Nelson, who organized in 1993 the book *National Innovation Systems: a Comparative Study*.

A Sistem of Innovation (SI) is composed by all the economic, social, political and organizational elements that have an influence on the development, diffusion, and utilization of innovation, generated through the learning process that occurs in interactions between institutions that exchange knowledge and technology (Edquist, 2001). The main components of a SI are the organizations and institutions. The organizations are the components consciously created by the actors, with explicit objectives (companies, educational and research institutes and public promoting agencies, for example). The institutions comprehend a set of routines and rules that regulate the interactions (marketwise or not) between the organizations (for example: rules of intellectual property, ethics codes, commercial laws, technological transfer contracts, etc).

The innovation induced by the creation of interinstitutional collaborative arrangements that manage the virtuous cycle of learning and technological transfer can be facilitated by the formation of sectorial innovation systems (Malerba, 2002). These Si's include diverse components with specific functions (Hekkert *et al*., 2007): development and diffusion of

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[3]The author also considers that induction can be achieved by an anchor firm (*Top down* network). In the example cited in the article (Petro-RS Network), the anchor company is Petrobras, who coordinates a network of suppliers and laboratories.

[4]A system in formed by components and by the relationship between the components. It is always a simplification of reality, due to the practical necessity in defining the components and system limits in an arbitrary and idealized manner (Edquist, 2001).

knowledge; influence on the direction of new technology searches; promotion of experimental ventures; market formation; human and financial resource mobilization; legitimating of new technologies and generation of positive externalities. Thus, the definition of functions of a SI is a management instrument that helps to define the attributions of their components, as well as controlling the execution of these functions.

The concept of Triple Helix is an explanation model of the multiorganizational innovation process presented in 1995 by Henry Etzkowitz and Loet Leydesdorf in the article *The Triple Helix of University-Industry-Government Relations: A Laboratory for Knowledge Based Economic Development*[5] (Leydesdorf and Etzkowitz, 1996). The model points out the role of universities as the central agent of the innovative process in knowledge-intensive economies, role induced by institutional innovations created by the government that pursues approaching universities to companies[6] (Etzkowitz and Leydesdorf, 2000).

Therefore are identified the three helices of the model: universities, companies and government. The relations between the helices can undertake three forms (Etzkowitz and Leydesdorf, 2000): the triple helix I, characterized by government control over universities and companies; triple helix II, in which the institutions are sharply separated and where relationships are circumscribed to eventual contracts (liberal model, counterpoised to triple helix I); and triple helix III, represented by the juxtaposition of the three spheres, which means that each one of the spheres assume roles traditionally attributed to the others: for example, the university leading multiorganizational arrangements, the government producing or consuming goods and companies generating scientific and technological knowledge in their field of interest. Simplifying, the triple helix model searches to understand the relationships between these three actors, that combine and recombine themselves constantly in forms that adapt to the conditions of human resources, financial constraints and technology transfer.

The concept of organizational ecosystems refers to the tradition of economists of several schools of thought that stresses the similarities between biological evolution and economic development (Corallo and Protopapa, 2007).[7] The authors attribute the first utilization of the term "business ecosystem" to the article *Predators and Prey: A New Ecology of Competition*, published by James F. Moore in 1993 in the *Harvard Business Review.* According to Moore, a firm is not only a member of a specific industry, but part of a business ecosystem that involves several industries, where the capabilities evolve conjointly around a set of technologies produced by these firms.

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[5]The article was published in the *European Association for the Study of Science and Technology Review*, v.14, n.1, 1995, p. 11-19.

[6]In the authors points of view, the inclusion of universities as agents of economic development (the "third mission" of the academy) represents a academic revolution comparable to that occurred in late XIX century, when research ("second mission") was introduced as a complementary academic mission to education ("first mission").

[7]Corollaro and Protopapa (2007) observe two problems in the use of biological analogies in economics: firstly, the biological evolution does not have goals as well defined as economic development; secondly, complex species do not combing through crossbreed; in the other hand, economic systems very often combine artifacts and competencies. Even though these limitations, the authors consider that this does not invalidate biological ecosystems as a metaphor to the comprehension of multiorganizational networks.

Kay *et al* (1999) define organizational ecosystems as complex systems (non explainable by linear relations of causality), ecosystems called by the authors as Self-Organizing Holarchic Open Systems (SOHO).[8] This systems are characterized by permanent interaction between their components, by flexible hierarchies and by constant reconfiguration of one organizational state to the other. This instability requires and promotes a constant and adaptative learning, fundamental in rapidly changing environments composed by heterogeneous institutions, such as innovative organizational ecosystems.

The concept of SOHO organizational ecosystems considers the idea of managers as omniscient coordinating agents to be a negative factor for the sustainability of organizational ecosystems, since it creates a inertia harmful to dynamic learning and doesn't take in regard the need for adaptive learning, monitoring and constant adjustments of the structures of governance. In this manner, the efficient management of organizational ecosystems requires the constant identification of changes in the environment and available resources, planning interventions that facilitate the system's self-organization. Depending on the particular characteristics of each actor, these interventions must be performed taking into consideration the forces that give cohesion to the group. These are called on by the actors as attractors,[9] and they are nothing more than the objectives and aspirations of the components of an ecosystem that are responsible for its maintenance in a specific domain of activities. Therefore, the creation or maintenance of attractors is an instrument to maintain or change the state of an ecosystem (attractors to stimulate scientists focused on academic production to dedicate resources and time to entrepreneurial activities, for instance).

The SOHO organizational ecosystems have as an inherent characteristic the uncertainty of the motivations and behavior of the actors, thus resulting in the impossibility to accomplish any "anticipated" management system, capable of predicting the decision's consequences. The solution presented by Kay *et al* (1999) is to utilize management schemes that take under consideration the possibilities of complex systems, characterized by the following elements: 1. The actors and their context; 2. The hierarchical characteristics of the system; 3. The attractors that delimit the "orbit" of the system, and how actors respond to the attractors; 4. the entries and exits of information and resources that organize the ecosystem around the attractors, concerning attractive forces as well as forces of repulsion.

With this concept in mind, the authors propose a manual to plan and manage organizational ecosystems, composed by stages of action divided into subtasks (table 1).

The concepts here presented are quite functional as conceptual and methodological guides in implementing multiorganizational arrangement management models for technological transfers towards innovation, and coherent with the approach of research-action that motivated the elaboration of this chapter. The next item will present an organizational ecosystem management model that will absorb the contributions of this approach, illustrating the proposition with the experience of Coordination A.7.: Knowledge Transfer to the Public Sector within INCT/NAMITEC.

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[8] *Self-Organizing Holarchic Open Systems.* The term holarchic designates systems where the components are, simultaneously, a part and the whole system, in continuous interaction.

[9] The term attractor is an analogy to the forces of gravity, which maintain the planets circumscribed to their orbits.

A. Characterization of the ecosystem
1. Definition of the analysis perspective (economical, management, cultural) and scope (limits of description).
2. Definition of the processes that define the ecosystem.
3. Definition of the actors and of their vertical and horizontal relationships.
B. Description of the ecosystem as a self-organizing entity.
1. Characterization of the attractors associated to the existent organizational states.
2. Assessment of development trends of the ecosystems
3. Evaluation of the reactions of members of the ecosystems to different attractors.
4. Identification of possible changes in the attractors.
5. Characterization of resource and information flows (entry and exit).
6. Identification of synergic relations and characterization of resource swaps.
C. Evaluation of the ecosystem's sustainability as a function of the proposed goals and objectives.
1. Identification of acceptable states of the ecosystem as a function of the proposed objectives.
2. Identification of the economical, technical, political, etc. processes necessary to fulfill the proposed objectives.
3. Identification of inacceptable attractors, desirable actors and possible tradeoffs involved in the choosing of the actors.
D. Maintenance of the integrity (sustainability) of the ecosystems.
1. Identification of actions to mitigate threats to the integrity of the ecosystems.
2. Identification of actions to promote positive attractors.
3. Definition of ecosystem monitoring actions to detect changes.
E. Actions to deal with the complexity of the ecosystems.
1. Elaboration of anticipative management schemes that allow adaptation to changes based on organizational learning.

Source: Adapted from Kay *et al* (1999)

Table 1. Step-by-step for planning/management of SOHO organizational ecosystems.

3. INCT/NAMITEC's management model: Proposal of a knowledge transfer model to the productive sector

The Ministry of Science, Technology and Innovation (MCTI) in Brazil has been using the scientific-technological network model frequently in the application of resources towards fomenting Science &Technology activities. Between 2001 and 2009, eleven public calls for research projects of MCTI were facing specifically the promotion of this type of arrangements (SIGCTI, 2011). Aligned with this model, the MCTI Ordinance n° 429/2008, that established the National Institutes of Science and Technology Program (INCTs), clearly shows that the management model adopted by the INCTs is based on the concept of science and technology network:

Art. 2nd. The National Institutes will be formed by a host institution, characterized by the excellence of its scientific and/or technological production, high qualification in the formation of human resources and with the capacity of leveraging resources from other sources, and by a set of laboratories or associated groups to other institutions, articulated **in**

the form of scientific-technologic networks. (MCT Ordinance n° 429/2008, author highlight).

An example that illustrates the possibilities of multiorganizational cooperation in microelectronics is the explanation given by Saxenian (1990) for the resumption of competitiveness of the United States Silicon Valley companies in the 1980's. In the author's view, it was neither the companies separately, neither the Government alone the promoters of the region's recovery, but the emergence of collaborative networks between specialized producers and a collective learning process inside these networks.

"The dynamics of Silicon Valley´s revitalization are reflected in this new wave of semiconductors start-ups. These firms, together with hundreds of neighboring technology firms, are forging a flexible model of production in the region. By building on the social networks and industrial infrastructure which were created and then abandoned by the established semiconductor firms, these small and medium-sized enterprises are pioneering a new Silicon Valley- one which fosters collaboration and reciprocal innovation among networks of specialist producers" (Saxenian, 1990: (89-90)".

In Brazil, the microelectronic industry is still an incipient one, and has been weakening since the end of the 80's, when there were 23 active companies in the semiconductor sector in Brazil. Since then, both R&D and industrial activities suffered a sharp reduction. This weakening becomes evident in the sector's deficit trade balance: in 2009, the country has imported an amount equivalent to US$ 3,2 billions in semiconductor components; on the other hand, in the same year the exports reached only US$ 57 million (Swart, 2010).

This fragility, in addition to the microelectronic industry's strategic and economic relevance, guarantied its inclusion in the public policy agenda (Swart, 2010). Table 2 resumes these initiatives, aimed towards the formation of human resources, creating integrated circuit project companies (*design houses*) and setting the regulatory framework in order to induce private investments in this industry.

Year	Action
2002	Launch of the National Microelectronics Program.
2004	Inclusion of semiconductors amongst the priorities of the Industrial, Technological and Foreign Trade Policy (PICTE).
2005	Creation of the CI-Brasil Program, targeted to human resources formation.
2007	Inclusion of the area of electronic *displays* amongst PICTE's priorities.
	Creation of the Semiconductor Industry Technological Development Support Program (PADIS).
2008	Inclusion of the microelectronic field in the Science, Technology and Innovation Action Plan.
	Creation of the National Center of Advanced Electronic Technology (Ceitec).
	Creation of INCT-NAMITEC.

Source: Swart (2010), adapted

Table 2. Incentives to Brazil's microelectronic industry.

Within a group of joint actions proposed to stimulate the microelectronic industry's development, the creation of INCT/NAMITEC in 2008 continued NAMITEC's project of Institutes of the Millennium[10], of 2005. NAMITEC counts on several educational and research institutes in the fields of physics, chemistry, computer science and electric/electronic engineering. Nowadays NAMITEC is constituted of 137 researchers of 27 departments in 23 institutions in 13 Brazilian states (INCT/NAMITEC, 2011).

NAMITEC has as its host and coordination institute the Center for Information Technology Renato Archer (CTI). It is managed by a committee composed by five members of different institutions. Its research activities are organized in eight coordination areas, being five technological and three administrative ones. (Table 3).

Field	Specific Area
Technological Development	A.1. Wireless sensor networks.
	A.2. Integrated circuit projects and library of intellectual property.
	A.3. Automatic integrated circuits projects.
	A.4. Semiconductor's material.
Administrative	A.6. Human resource formation.
	A.7. Transfer to the productive sector.
	A.8. Transfer to society.

Source: Adapted from INCT/NAMITEC (2010)

Table 3. Research areas of INCT/NAMITEC.

The network was conceived having as an integrator axis the technologies of wireless sensors networks, correspondent to the first area of technological development (A.1.). The other areas were conceived to subsidize the production of autonomous electronic systems (intelligent sensor network, embedded systems and self-adjustable systems), and contemplate all the necessary knowledge in research to develop wireless sensor network, ranging from materials and fabrication techniques to integrated circuits projects and intellectual properties library. The coordination and interaction mechanisms between NAMITEC's participants are briefly described in Table 4.

Coordination	Area Coordinators receive quadrimestral reports from project coordinators in order to evaluate and elaborate each areas reports
Interaction	Resources for exchange between NAMITEC's members and other INCTs. Support the participation in events are granted only for papers with inter-institutional co-authors. Post-doctoral scholarships are restricted to collaborative projects

Source: Adapted from INCT/NAMITEC (2010)

Table 4. NAMITEC's coordination and interaction mechanisms.

NAMITEC's network gives an important contribution to the formation and of human resources in the field of microelectronics, which is the scope of action of coordination A6,

[10]The Program Institutos do Milênio was transformed in the Progama de Institutos Nacionais de Ciência e Tecnologia by the ordinance MCT n°429/2008.

and of diffusion of the microelectronic area to society, object of coordination A.8. The indicators of academic production and human resource formation in postgraduate levels are significant and synthesized on Table 5.

Indicators	**Number**
Books	14
Chapters in Books	34
Articles in national journals	22
Articles in international journals	175
National conferences	270
International conferences	274
National summaries	46
International summaries	30
Softwares	1
Product patents	7
Processes patents	1
Technical bulletins	1
Concluded scientific initiations for undergraduate students	59
Concluded Master degrees	103
Concluded PhDs degrees	30
Concluded Postdocs	12
Scientific initiations for undergraduate students in progress	102
Masters in progress	138
PhDs in progress	123
Postdocs in progress	22
Concluded oriented graduations	35
Scientific Conferences organized	12
NAMITEC Colloquiums	6
Short term courses	8
Courses ministered in events	8
News in the open media	8
Lectures/round tables	71
Participation in fairs and workshops	11

Source: INCT/NAMITEC (2011)

Table 5. NAMITEC: Indicators of HR formation and diffusion.

The coordination A.7. (Knowledge Transfer to the Productive Sector) has as its objective to develop strategies and actions aiming to enhance the transfer of technology developed in NAMITEC to the productive sector. In order to do so, several strategies are applied, including direct contact with the companies, arrangement of meetings with business associations and participation in events. As a result, cooperation arrangements have been firmed with the twenty eight companies listed on Table 6.

Company	NAMITEC Institution
Pronatus Amazônia	Center for Science, Technology and Innovation of Manaus Industry Center (CT-PIM)
Datacheck	Center for Information TechnologyRenato Archer (CTI)
Curitiba International Center for Software Development	CTI
Vale do Rio Doce Company University (Univale)	CTI
Transpetro/Petrobras	Rio Grande do Sul Federal University/Engineering School (UFRGS/EE)
ARM	UFRGS/EE
Texas Instruments (USA)	UFRGS/EE
Amplivox	Santa Catarina Federal University (UFSC)
Potychip	UFSC
Tydex (Russia)	Mackenzie University
INO (Canada)	Mackenzie University
Embú Scientific	(Integrated Systems Laboratory / São Paulo University (LSI/USP)
Dixital Technology	LSI/USP
KBA	LSI/USP
High Comm	LIS/USP
LG Electronics	LIS/USP
Novus Electronics	LIS/USP
Treetech Digital Systems	LIS/USP
Digicrom Analyses	LIS/USP
Brasília Technology	Brasília University (UNB)
Z Technology	Integrated Circuits and Devices Laboratory (LDCI)/UNB
Wise Informatics	LDCI/UNB
Tipo D engineering services	LDCI/UNB
Digital Technical Systems	LDCI/UNB
DFChip	LDCI/UNB
Hewlett-Packard Laboratories	LDCI/UNB
São Francisco hydropower company	Electrical Engineer Department/ Campina Grande Federal University(DEE/UFCG)
Tocantins power company	DEE/UFCG

Source: Adapted from INCT/NAMITEC (2010)

Table 6. NAMITEC´s cooperative arrangements with private companies.

The interactions with the productive sector occur by establishing agreements between NAMITEC participant institutions and companies, aiming towards technology and knowledge transfer. These interactions can be classified accordingly to Table 7, which shows the distribution of the types of interactions in the 41 company cooperative projects.

Types of Interactions	**N° of cases**
Know-how transfers on product fabrication	19
Process and equipment transfers to the productive sector	15
Analogical, digital and radio frequency Intellectual Property Libraries (IP)	1
Workshops	6

Source: Adapted from INCT/NAMITEC (2010,2011)

Table 7. Types of interactions: NAMITEC Institutions with the productive sector.

The interactions with the companies may be considered peripheral, since these are not institutions that directly integrate the NAMITEC network. Despite the fact that the five technical areas of INCT/NAMITEC are integrated logically in a productive chain, each institution develops interactions with the companies in an isolated manner, thus not involving any of the remaining institutions within NAMITEC.

The network formed by NAMITEC is essentially an academic network, since the majority of the participating institutions are public institutions of education and research, promoting an important scientific cooperation in the formation of human resources as well as in scientific and technological production (articles, patents and *softwares*) (Table 5).

These characteristics indicate that in NAMITEC, as conceptualized by Callon (1992), the emphasis is on the scientific pole (production of knowledge) and the technological pole (application of knowledge). It lacks, however, an active participation of the market pole, including the companies and users that materialize the innovation. In the INCT/NAMITEC network, the majority of exchanged intermediaries between the poles (that mediate the interactions of the actors) are academic documents, lectures and courses objectifying human resource formation and bound to events directed to scientific production.

In order for NAMITEC to promote innovative activities, it is necessary that the private companies assume a bigger role in this network, as proposed by the network concept by Castells (1996, *apud* Corallo e Protopapa, 2007). Furthermore, joint and coordinated action by the Government and the Education and Research Institutions are required so that the several organizations that are a part of the Brazilian microelectronic sector's organizational ecosystem[11] acquire a beneficent convergence to the generation of useful innovations for the society as a whole. Be it in the form of a Horizontal Network of Induced Innovation (Pellegrin *et al*, 2007) or a Triple Helix (Leydesdorf e Etzkowitz, 1996), a broader interaction between the actors is necessary.

In Brazilian's microelectronic industry, the challenges are even greater, given the fragilities of the companies. Nowadays there are in Brazil seven Design Houses and two designer training centers created within the CI-Brasil Program. In the other segments in the semiconductor's production chain, and specially the participant companies in the sector, Brazil still in industry infancy:

> "However, there isn't a single semiconductor manufacturer that has benefited from the Informatics Law. This finding, combined with the fact that today the semiconductor segment counts on only one SDRAM memory encapsulation plant, two discrete semiconductors (isolated components, not integrated circuits, such as diodes, transistors, etc, for instance, for the fabrication of power supplies) and one integrated circuit design company, belonging to a multinational company, clearly shows the amount of effort that the country needed and needs to **create and develop a microelectronic ecosystem** in Brazil" (Swart, 2010, 276; authors' emphasis)

In order to overcome the difficulties of creating a microelectronic ecosystem in Brazil, NAMITEC's Coordination A.7. established a set of objectives, which unfold into three macro-functions with the goal of beaconing management activities of technology transfer in the NAMITEC network (Table 8). In essence, these macro functions have as a final purpose to act on the ecosystem that the public and private institutions of NAMITEC are inserted, creating attractors that stimulate the cooperation towards innovation and mechanisms that allow the planning and efficient management of the organizational ecosystem delimited by the integrating institutions of INCT/NAMITEC (Kay *et al,* 1999).

With these efforts, the idea is to induce the diverse actors in the ecosystem to the state desired by Coordination A.7., stimulating collective and interactive learning in the participating institutions (academies and firms) in order to circulate the knowledge that has the potential of generating innovations that strengthen the Brazilian microelectronic industry. The organizational ecosystems concept adopted in the management model proposed by Coordination A.7. does not consider the technology transfer activity a unilateral relation, in which knowledge flows from the Educational and Research Institution to the productive sector. Coordination A.7. sees the NAMITEC network as a self-organizing ecosystem (Kay *et al*, 1999), where changing to a desirable state depends on collective learning processes, highlighting the continuous organizational learning of all the components of the ecosystem: Network managers, researchers, demanding companies of NAMITEC's technologies and government institutions.

[11]The challenges in integrating multiple actors towards an innovative action in Brazil, mainly in the private sector, are a part of the characteristics of our Sistema Nacional de Inovação (National Innovation System). The integration between universities/research institutes and companies are especially problematic (Velho, 2004; Rapini, 2007; Lotufo, 2009).

Macro Function	Actions
Enhance NAMITEC's cooperation and intern alignment.	Map purposive and supportive knowledge/technology. Identify actual and potential relationships between researchers and technologies. Stimulate cooperation and new projects of common interest. Identify the technological areas with greatest integration potential. Comprehend the potential synergies existent amongst groups that may facilitate the diffusion of knowledge and organizational learning. Develop means to stimulate greater levels of cooperation between research groups. Enhance comprehension on the complex relationships between organizational learning, technology development and innovation in INCTs. Identify mechanisms to enhance diffusion of knowledge.
Enhance alignment of NAMITEC's technologies with company demand.	Initial survey on the potential applications of existent technologies. Verify technological areas with greater potential of application/transfer to companies. Provide conditions so that NAMITEC's technologies can leverage companies. Identify company demands that mobilize new research in NAMITEC. Identify NAMITEC's most demanded technologies (purposive and supportive).
Develop means to potentiate the assimilation process of NAMITEC's technologies by the companies.	Map company demand. Enhance the comprehension on organizational learning relationships, technological development and innovation in the cooperation processes with the companies. Develop mechanisms to enhance the organizational learning processes within NAMITEC and in the technologic transfer activities. Make means available in order to integrate organizational learning processes to labor activities in the target organizations (of the productive sector). Publicize NAMITEC technologies. Identify mechanisms to enhance diffusion of knowledge outside NAMITEC. Stimulate university-company cooperation. Contribute to a greater level of cooperation amongst research groups (suppliers) and the productive sector (demand). Foment complementary projects. Study more effective transfer mechanisms. Study protection of intellectual property mechanisms.

Source: Coordination A.7./NAMITEC (2009)

Table 8. Macro functions of NAMITEC's Coordination A.7.

4. Organizational ecosystems: The participatory approach

The concept of organizational ecosystems can be a very effective management instrument. The management of people is necessary to fulfill the required functions of generation and dissemination of innovation within Namitec, in a way that it allows the integrated management of several important institutions within this process. So, to give practical substance to the case study presented in this chapter, it is presented a brief view of what has been called by Balloni et al as "the six characteristics of the participatory organizacional ecosystem" (Balloni, 2011). These six characteristics are suggested to be adopted as a model for organizational ecosystem, such as the INCT/NAMITEC:

1. Open and lateral dissemination of know-how.
   To facilitate teamwork, every participant must be encouraged to engage in yokoten (a short for yokoni tenkaisuru), which literally means "unfold or open out sideways."This approach encourages everyone to share their individual know-how and expertise openly with others.
2. Freedom to voice contrary opinions.
   The organization (private and/or public managers) should also be open to criticism and contradiction for the nerve system (which we call here as "Organizational Ecosystem") to function properly. This means everyone has to feel free to voice contrary opinions, even to top management and headquarters.
3. Frequent face-to-face interaction.
   Any managers to reach senior positions have a must to acquire and embrace the skill of listening thoroughly and intently to what employees have to say and continually questioning and probing to find a better way.
4. Making tacit knowledge explicit: Organizational Ecosystem.
   Tacit knowledge is converted to explicit knowledge every time someone verbalizes or writes down the knowledge he or she has.
5. Formal and informal organizational support mechanisms.
   Formal and informal support mechanisms have been established in the organization to contribute to the effective functioning of the nerve system.
6. The current global economy, driven by accelerated growth strategy, is unsustainable since it leads to the population bomb ("more customers" is good for business), ecological bomb, and eventually to the depletion of strategic resources bomb. Today civilization faces - the *gene* versus *mind* evolutions and *globalization* versus *sustainability*. Hence, the following principles-strategies of the wise civilization should be applied to steer long and short-term planning and execution of national goals, objectives, and targets (Balloni, 2011). Where among equals, the ecosystem is more equal**;** Cognizing (education) **and** Ecoism is a new world business system, which would provide the preference to the ecosystem, not to the capital (capitalism) or social prosperity (socialism)**.** The nation-state concept should be sustained in order to prevent diversity of the world society and secure cultural heritage of nations**.** The Knowledge-Wise Society, which should promote the education, cognition, and knowledgeable and wise decision making and wise use of e-Global Village, which should support the *mind* evolution and also vice versa, is supported by the *mind* evolution to promote the sustainability of any Organizational Ecosystem.

These 6 key principles-strategies above, if adopted as a model for Organizational Ecosystems such as INCT/NAMITEC, should lead to the development of a wise ecosystem. These principles-strategies should be incorporated into all level of NAMITEC decision-making. In short, these key principles-strategies should lead to the development of a sustainable Organizational Ecosystem. The accountability is now in the management system of an Organizational Ecosystem instead of in the hands of the manager (peoples).

5. Conclusion

The inherent complexity of innovation, the diversity of required competences to develop them and the high costs of contemporaneous innovative processes have led public and private institutions to adopt multiorganizational cooperation as a tool to make viable the development of innovations. Such arrangements, however, do not guarantee the achievement of such objectives, due to the difficulties of interaction and alignment between heterogeneous institutions.

Several studies and concepts deal with the virtues and difficulties of multiorganizational arrangements. The concepts examined in the present chapter are a small part of these studies. However they help to clarify some of the difficulties in the multiorganizational arrangement chosen as a case study: the INCT/NAMITEC. It may stated the concept of organizational ecosystems can be a very effective management instrument, managing the people necessary to fulfill the required functions of generation and dissemination of innovation in a way that it allows the integrated management of several important institutions within this process, as pointed out by NAMITEC case.

The multiorganizational arrangement created by NAMITEC has a fundamental part in the training of human resources and in the generation of scientific and technological knowledge, since it is composed by the main universities and research institutes in Brazil. However, Callon's (1992) concept of techno-economic networks allows the pinpointing of a weakness in this network: the lack of a market pole, where innovation becomes effective. In Castells network concept (1996, *apud* Corallo and Protopapa, 2007) this weakness is in the peripheral position that private companies have in NAMITEC. Speaking in terms of Innovation Systems (Edquist, 2001; Malerba, 2002), the weakness resides in the Brazilian Sector System of Innovation in microelectronics: the fragility of the national industry in this field (Swart,2010).[12] And finally, the concept of Triple Helix (Leydesdorf and Etkowitz, 1996; Etkowitz and Leydesdorf, 2000) reveals that the multiorganizational arrangement created by NAMITEC refers to the type I triple helix, where the companies are seen as users of the technologies generated in the Educational and Research Institutions, without a active participation in the innovative process, fact that makes the appropriation of these technologies by the productive sector, during the transfer process, quite difficult.

In short, this chapter shows ways to improve NAMITEC's management. Pellegrin's *et al* (2007) propositions indicate that the presence of one or more inducting agents (anchor) would be desirable to stimulate cooperation between agents, thus acting in a convergent manner (Callon, 1992) in generating innovations. In the words of Hekkert *et al,* (2007), to create stimulus for the components (actors) of Brazil´s sector system of innovation in microelectronics in fulfilling the necessary functions to the completeness of the innovative process.

The theories presented in the chapter suggest actions aiming to improve the interaction and alignment between the diverse acting components in the multiorganizational arrangement created by NAMITEC. These suggestions align themselves to the concept of organizational ecosystems (Kay *et al,* 1999), complex systems composed by heterogeneous actors, where the change to a desirable state dispenses coordination actions. However, the concept of organizational ecosystems goes beyond, characterizing such systems as self-organizing, where adaptive learning of the involved allow them to deal with constant change, be it change in the components or the environment in which the ecosystem is inserted. Such knowledge represents a change from an "anticipatory" management scheme to an "adaptive" management scheme.

[12]Actually, the Brazilian industry of microelectronics assembles "national" equipment composed by imported components (Gutierrez and Alexandre, 2003).

Considering the participatory approach (see section 4 of this chapter) two weakenesses can be pointed out in NAMITEC´S network: firstly, the lack of open and lateral dissemination of know-how, due to the poor communication mechanisms between researchers and interested companies. Secondly, face to face interaction is not as frequent as it should be: NAMITEC´s researchers only discuss collectively network issues in Namitec workshops, that occur twice a year.

With this vision of organizational ecosystems, coordination A.7. generated a proposal aiming to promote interaction and alignment between actors in the technology transfer process that occur within INCT/NAMITEC. The proposal involves a set of activities in three macro-functions: enhance cooperation and alignment between participating institutions in NAMITEC; enhance alignment of NAMITEC generated technologies with demands of the productive sector; create mechanisms that allow assimilation by the productive sector of the technologies generated by NAMITEC network.

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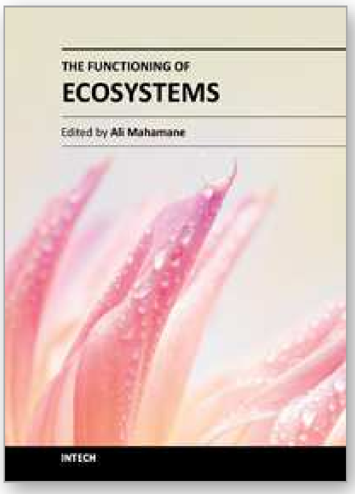

The Functioning of Ecosystems
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The ecosystems present a great diversity worldwide and use various functionalities according to ecologic regions. In this new context of variability and climatic changes, these ecosystems undergo notable modifications amplified by domestic uses of which it was subjected to. Indeed the ecosystems render diverse services to humanity from their composition and structure but the tolerable levels are unknown. The preservation of these ecosystemic services needs a clear understanding of their complexity. The role of the research is not only to characterise the ecosystems but also to clearly define the tolerable usage levels. Their characterisation proves to be important not only for the local populations that use it but also for the conservation of biodiversity. Hence, the measurement, management and protection of ecosystems need innovative and diverse methods. For all these reasons, the aim of this book is to bring out a general view on the biogeochemical cycles, the ecological imprints, the mathematical models and theories applicable to many situations.