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THE TRIPLE HELIX MODEL AS A BASIS FOR THE DEVELOPMENT OF A LOCAL PRODUCTIVE ARRANGEMENT (TECHNOLOGY CLUSTER) IN BRAZIL

KEY-WORDS: Triple Helix, Cluster, Innovation, Regional Development

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Introduction

In today's world, innovation and knowledge are the main factors that determine the competitiveness and development of nations, regions, sectors, companies and even individuals (CASIOLATO; LASTRES, 2000). Knowledge and technology have become increasingly complex, increasing the importance of interactions between companies and other organizations as a way to acquire knowledge (MANUAL DE OSLO, 2005). In this context, the term "knowledge economy" was coined to describe the trend of advanced economies in creating dependence on knowledge, information and the high levels of specialization, leading to a growing need for immediate access to these factors by the public and private sectors (MANUAL DE OSLO, 2005).

In addition to the recognition of the roles of innovation and knowledge for development, other issues also contributed to a better understanding of the innovation process in recent years, most notably: (i) the understanding that innovation is in the process of searching and learning, being strongly influenced by specific organizational and institutional forms; (ii) the understanding that there are important differences between the innovation systems of countries, regions, sectors and organizations in relation to each specific social, political and institutional context; (iii) the view that, despite the information and communication technologies allow an efficient dissemination of information and codified knowledge, tacit knowledge of localized and specific character still have a vital role for innovation and remain difficult (if not impossible) to be transferred (CASIOLATO; LASTRES, 2000).

The finding that a knowledge-based view focuses on interactive processes through which knowledge is created and exchanged within companies and between companies and other organizations has led to the expansion of collaborative arrangements, the increasing expansion of industrial networks and a greater integration with the production centers of knowledge, aspects identified among the major trends for the current innovative processes (CASIOLATO; LASTRES, 2000).

As a consequence, the formation of interaction networks has been considered the most appropriate organizational format to promote the intensive learning and generate knowledge and innovations, such as productive clusters and the environment where they settle. In this format, the process of innovation is understood as interactive and dependent on the different characteristics of each agent and its ability to absorb and generate knowledge, the articulation of different actors and sources of innovation as well as the environments where they are located and the level of tacit knowledge existing in these environments (LEMOS, 2003).

Thus, the creation of innovative regions appears as a common objective anywhere in the world that seeks to develop its economy based on knowledge. An innovative region is the one that has the ability to move through technological paradigms and periodically renew itself through new technologies and new companies generated from an academic basis (ETZKOWITZ; KLOFSTEN, 2005).

Based on the thought of Schumpeter (1950) that the innovative capacity is dependent upon the construction and institutionalization of a heterogeneous network of public and private

entities that can provide business formation expertise, “gaps” funding, seed capital and collective entrepreneurship, Leydesdorff and Etzkowitz (1998) proposed the Triple Helix model to describe the dynamics existing in the institutional arrangements involving universities, enterprises and governments and the relations between them occurring during the processes of innovation (ETZKOWITZ; LEYDESDORFF, 2000 and ETZKOWITZ; KLOFSTEN, 2005). In fact, the interactions between university, industry and government - the Triple Helix - may be regarded as a key factor for regional development, given that besides the ability to research in emerging areas and interdisciplinary fields with commercial potential, they also include the ability to effectively use these knowledge resources (ETZKOWITZ; KLOFSTEN, 2005)

Having understood the importance of these issues in the regional development context in Brazil and based on the fact that the heart of the Triple Helix model is the understanding of how university, industry and government can interact to strengthen the innovative capacity of a region/nation (DOOLEY; KIRK, 2007), this study aims to reflect on the existence of the Triple Helix Model in a Local Productive Arrangement (LPA) of Electronics located in the South of Minas Gerais, Brazil. It aims to identify the roles and relationships between the three elements that make up the model - university, industry and government and the reflection of these relations on technological innovation and development.

The paper begins with a literature review on the concepts related to innovation, local production and innovation systems and the Triple Helix model. Next, we present the APL of Electronics of Santa Rita do Sapucaí, focus of the study and, based on surveys of primary and secondary data along with the main players that comprise the APL, we analyzed the innovation process that occurred in such location and relate this process with the Triple Helix model. Finally, we present the conclusions and final considerations resulting from the study.

Local Productive and Innovative Systems

The modern innovation process is the result of the interaction between agents of different natures and interests. Knowledge networks should be able to articulate and manage the different abilities of these players in order to achieve success in the design and implementation of innovations (MAMÃO, 2007). It is important to consider that an innovation only produces comprehensive economic impact when it is widely spread among companies, sectors and regions, giving rise to new projects and creating new markets (TIGRE, 2006).

The systemic view of innovation considers the influence of external institutions on the innovative activities of companies and other players, emphasizing the importance of transfer and dissemination of ideas, experiences, knowledge, information and signs of various kinds. Innovation is seen as a dynamic process in which knowledge is accumulated through learning and interaction (MANUAL DE OSLO, 2005).

Systemic approaches to innovation shift the focus of previous policies based on a dichotomous and linear view of innovation, in which the innovation process would begin in the scientific institutions and then be transferred to the production sector. In the systemic view, the

emphasis is on the interaction between institutions and in the interactive processes of creation, dissemination and application of knowledge, aiming to enhance learning and innovation (LASTRES, 2004).

Policy makers that promote the economic and social development around the world have sought to grasp and understand the new forms of industrial and technological development, as well as to develop new strategies that will stimulate and guide them. In this context, the mobilization of productive agents in the form of collective players and within a systemic perspective stands out as one of the central strategies in the policies of all countries, particularly those less developed (REDESIST, 2010).

When analyzing the role played by micro and small enterprises in developing regions and countries and the importance of the innovation process adopted by them, it can be seen that the exploitation of the collective synergies generated by the participation in local arrangements and production chains favor the process of collective learning, cooperation and innovative dynamics, strengthening, therefore, the chances of survival and growth, thus providing an important source of sustainable competitive advantages (CASSIOLATO; LASTRES, 2004).

The phenomenon of concentration of competitive companies has been studied for nearly twenty years and received a number of denominations with slight differences between them, such as cluster, LPA and production chain. According to the definition proposed by RedeSist (2010), Local Productive and Innovative Systems (LPIS) are:

> *sets of economic, political and social agents located in the same territory, developing correlated economic activities that have significant production, interaction, cooperation and learning bonds. LPIS generally include companies - manufacturers of final goods and services, suppliers of equipment and other supplies, service providers, distributors, customers, etc. cooperatives, associations and representations - and other organizations focused on education and training of human resources, information, research, development and engineering, promotion and financing*[1].

Complementing this definition, RedeSist (2010) limits the term Local Productive Arrangements (LPA) to fragmented cases that do not show significant connections between the agents. Despite this difference in terminology used by RedeSist (2010), the term Local Productive Arrangement is the most used in Brazil, as explained in the following paragraphs.

According to the Permanent Work Group for Local Productive Arrangements (LPA) of FINEP[2] and also adopted by SEBRAE[3], productive arrangements are **clusters of companies** located in the **same territory,** which have specialized production and maintain a bond of articulation, interaction, cooperation and learning among themselves and with other local players such as the government, business associations, credit, teaching and research institutions.

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[1] Available at http://www.redesist.ie.ufrj.br, accessed July 10, 2010.

[2] Brazilian financier of studies and projects

[3] Support Service to Micro and Small Enterprises in Brazil

This definition points to six key aspects that characterize an LPA, which are: (i) the existence of a cluster with a significant number of companies that operate on a main productive activity; (ii) the territorial dimension; (iii) the tacit knowledge: expertise and knowledge that people and companies from a territory have on a major economic activity; (iv) interactive innovation and learning between different players - companies, firms and their associations, companies and technical, scientific and financial institutions, companies and the government and other possible combinations; (v) the presence of a governance focused on the articulation of cooperative, productive and innovative processes; (vi) the diversity of economic, political and social players (manufacturers of final goods and services, suppliers of inputs and equipment, service providers, distributors, customers, etc. class agencies, private and public education, research, consulting institutions, as well as political, promotion and financing institutions and the organized community in general) with actions directly or indirectly focused on the development of the local productive activity (SEBRAE, 2010).

According to Lastres (2004), the local productive arrangements and systems privilege: (i) the relationships between these sets of companies with other players; (ii) the knowledge flows, especially in its tacit dimension; (iii) the foundations of learning processes for the productive, organizational and innovative trainings; (iv) and the importance of geographical proximity and historical, institutional, social and cultural identity as sources of diversity and competitive advantages. In addition, in the methodology adopted by Sebrae (2010), productive arrangements can be classified into three different levels, depending on the stage of development in which they are found: incipient, under development or developed arrangements. The developed arrangements are those whose interdependence, articulation and consistent bonds lead to interaction, cooperation and learning, enabling the innovation of products, processes and organizational formats, thus generating greater business competitiveness and social training.

The developed LPA are those denominated by RedeSist (2010) as Local Productive and Innovative Systems and they present the following aspects as key differentials: (i) greater ability to attract new companies, suppliers, service providers, banks, etc; (ii) the leaderships operate, especially, in professional associations with formal relationships; (iii) there is a greater availability of financial resources offered by banks and financial entities; (iv) better structured companies invest more in the arrangement development, with their own and third-parties resources; (v) the presence of research centers and higher education institutions with specific proposals for the arrangement; (vi) the companies are more competitive and operate in other market levels (regional, national and international); (vii) implementation of territorial marketing initiatives.

The Triple Helix Model

Over the 90s, nations of different industrialization levels have formulated their innovation strategies based on the development of industry-academia relationships deliberated by the policies related to research and development (LEYDESDORFF; ETZKOWITZ, 1996).

Three models were developed during this period to study innovation: (i) the comparative approach of national innovation systems; (ii) the thesis of "Mode 2" of scientific knowledge production; (iii) and the Triple Helix of university, industry and government relations. While in the first approach the innovation systems have been solely defined in terms of institutional units of analyses and, in the second, in terms of reconstructions based on emerging perspectives of communication, the Triple Helix approach combines these two perspectives as different sub dynamics of the system under study and adds the market dynamics as a third perspective (LEYDESDORFF, 2006).

The Triple Helix has emerged from the analysis of the double helix industry-university and from the perception that the government was an essential part of the equation for innovation, even when it was suppressed for ideological reasons or had a very significant influence due to political requirements (ETZKOWITZ; ZHOU, 2006). That is, thinking about the modeling of knowledge infrastructure of a global system, Leydesdorff and Etzkowitz (1996) identified the existence of three dynamics - the economic dynamics of the market, the internal dynamics of knowledge production and the governance of the different interface levels and proposed a model of relations between university, industry and government, which they called Triple Helix[4] (LEYDESDORFF; ETZKOWITZ, 1996).

For the authors, the linear models expressed in terms of "market pull" or "technology push" were insufficient to induce the transfer of knowledge and technology. The rules and regulations had to be redesigned and an interface strategy was invented in order to integrate the "market pull" with "technology push" through new organizational mechanisms (ETZKOWITZ; LEYDESDORFF, 2000). It is also possible to observe that the evolution of innovation systems and the conflict about which path to take in the University-Company relations directly reflect on the variations of the institutional arrangements of the University-Industry-Government relations, leading to three distinct stages of the model, as shown below (ETZKOWITZ; LEYDESDORFF, 2000).

- Triple Helix I - Static model of the relations between University, Industry and Government: government encompasses academia and industry and guides the relations between them (socialist regimes, Latin America and a few European countries).

[4] Original name: "Triple Helix"

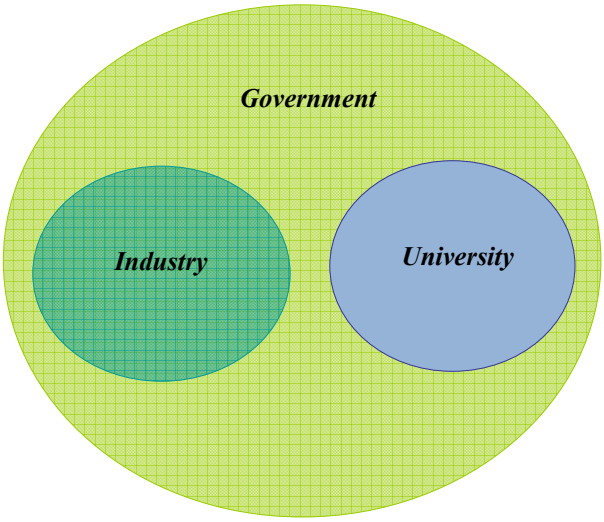

Figure 1 - Triple Helix Model I
Source: Etzkowitz & Leydesdorff, 2000, p. 111

- Triple Helix II - Model "laissez-faire" of the relations between University, Industry and Government: institutional spheres are separated by rigid boundaries that circumscribe the relations between them. The interaction occurs through industrial relations, technology transfer and official contracts.

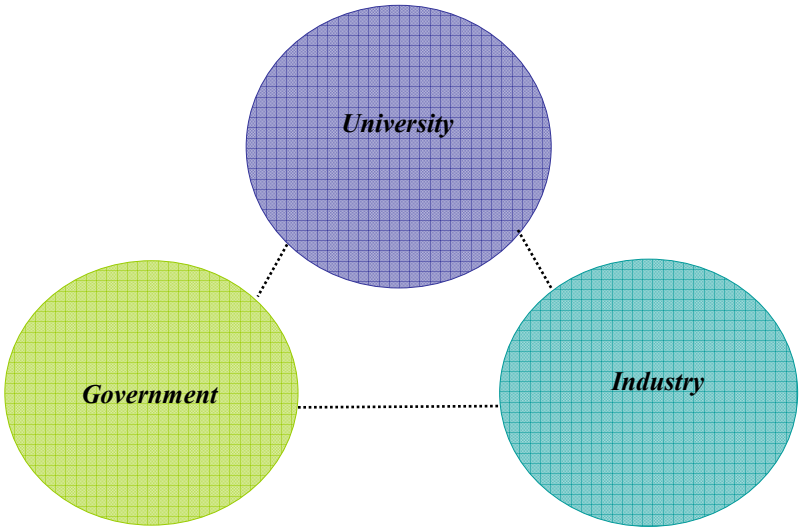

Figure 2 – Triple Helix Model II
Source: Etzkowitz & Leydesdorff, 2000, p. 111

- Triple Helix III – Model of inter-institutional relations between University, Industry and Government: creates a knowledge infrastructure in terms of overlapping institutional spheres, in which each one of them assumes the role of the other, with hybrid

organizations emerging on the interfaces (ETZKOWITZ; LEYDESDORFF, 2000). The triple helix model incorporates the dynamics of the elements (institutional spheres) in inter-institutional activities (ETZKOWITZ; LEYDESDORFF, 1999).

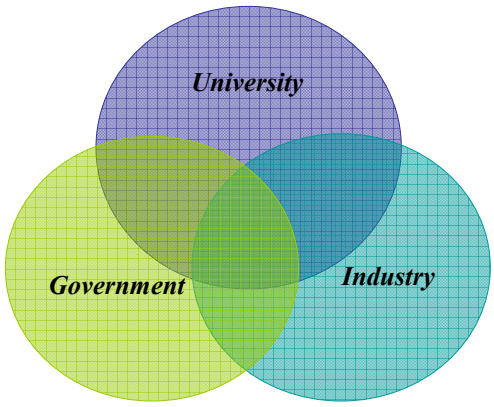

Figure 3 – Triple Helix Model III
Source: Etzkowitz & Leydesdorff, 2000, p. 111

In the innovation model of Triple Helix III, university, industry and government work together to achieve regional or national innovation based on science and technology, forming a mutually beneficial relationship between them. On the other hand, the model also supports the thesis that the university is increasingly a center for discontinuous innovation in knowledge-based societies, replacing the company as the main source of economic and social development of the future. The interaction between university-industry-government is the source of the origin and/or development of incubator movements, interdisciplinary research centers and venture capital, whether private, public or social (ETZKOWITZ; ZHOU, 2006). The model focuses on the overlapping of communications network and in the expectations on the remodeling of institutional arrangements between universities, industries and government agencies (ETZKOWITZ; LEYDESDORFF, 2000).

Understood as the authentic model of Triple Helix and adopted as such, stage III emerges from intensive relationships of increasing complexity that have emerged over the capitalization of knowledge, and is based on a complex set of organizational relationships between overlapped spheres, which increasingly break the boundaries between them. In addition to the connections between the institutional spheres, each sphere is increasingly able to assume the role of the other: universities start having entrepreneurial tasks such as market knowledge and the creation of companies, while companies develop an academic dimension, sharing knowledge and training their employees at higher levels of knowledge (LEYDESDORFF; ETZKOWITZ, 1998).

The increase of the interactions between the institutions lead to the generation of new structures within each one of them, such as incubators and companies and business centers in the universities or research centers in the companies and strategic alliances between different

companies. These interactions have also allowed the creation of integration mechanisms between the spheres in the form of networks, for example, researchers from academia, government with hybrid industry and organizations (LEYDESDORFF; ETZKOWITZ, 1996).

In the Triple Helix model, the university-industry-government network relations continually restructures the array of opportunities for a complex system that arises as a result of the reconstruction of different angles of each participant instance. All agents are involved in speeches of different levels, either within their respective institutions, in the specific interfaces of helices or in generalized levels where a third player may come to participate. The reflections are only partially synchronized by the network of relationships, enabling the participants to find niches in the knowledge-based economy (LEYDESDORFF; ETZKOWITZ, 1998).

In contrast to the Double Helix, it is not expected that the Triple Helix is stable. In the Triple Helix, where each sphere can relate to the other two, it is expected the development of an overlay of communications, networks and organizations among the helices (ETZKOWITZ; LEYDESDORFF, 2000). In other words, the sources of innovation that make up a Triple Helix are not synchronized a priori. They are not fixed in a predetermined order, thus creating puzzles to the participants, analysts and politicians to solve. This network of relations generates a reflexive sub dynamics of intentions, strategies and projects that adds value by reorganizing and harmonizing continuously the infrastructure involved (ETZKOWITZ; LEYDESDORFF, 2000).

The Triple Helix model includes three basic elements: (i) more prominent role of the university in innovation; (ii) collaborative relationships between the three institutional spheres; (iii) in addition to their traditional functions, each institutional sphere also plays the role of the other (ETZKOWITZ; KLOFSTEN, 2005). It is also possible to identify the existence of four processes related to the main changes in production, exchange and use of knowledge that emerge from the model, namely (ETZKOWITZ et al, 2000 and ETZKOWITZ, 2000):

(1) Internal transformation in each of the helices, such as the development of lateral ties among companies through strategic alliances or an assumption of an economic development mission by universities.
(2) Influence of an institutional sphere upon the other in the transformation performed.
(3) Creation of a new overlay of trilateral networks and organizations from the interaction among the three helices, serving both to institutionalize and reproduce the interface, and to stimulate organizational creativity and regional cohesion.
(4) Recursive effect of these inter-institutional networks representing academia, company and government, both on their originating spheres and the larger society.

Under the historical and economic perspectives, it is interesting to note that the Triple Helix model was derived from an analysis of the renewal of the economy in the U.S. city of Boston that took place in the 30s, through the collaboration between university, industry and government for the creation of companies based on academic research (ETZKOWITZ;

KLOFSTEN, 2005). In fact, among the various models of innovation based on knowledge, the Triple Helix model is the one that provides an analytical approach that allows the analysis of knowledge and interaction networks existing in the innovative processes at the national, regional, institutional and individual level (LU; ETZKOWITZ, 2008).

Aiming to optimize the potential for creation, distribution and production of knowledge, the Triple Helix model argues that interactive networks of innovation must be created among academia, business and government, so that (LU; ETZKOWITZ, 2008):

- Opportunities may be opened up for "brain circulation" and knowledge sharing between academics, companies' professionals and government managers.
- Academic research is linked with business practice and informed by real market demands.
- Entrepreneurial culture is developed and new start ups may be created from the Triple Helix innovation networks as a result of sharing knowledge between academia, industry and government.
- New policy initiatives may emerge from the networks, giving the government a better understanding of where the research is located, and thus enabling them to design policies to support new research areas.

The Local Productive Arrangement of Electronics of Santa Rita do Sapucaí

The Government's policy for LPA of Minas Gerais, a Brazil state, was effectively structured in recent years, especially since 2006, with the state law establishing the State Policy of Support for Local Productive Arrangements, and the installation, in 2008, of the Managing Center of Local Productive Arrangements (BOTELHO, 2010).

Regardless of federal and state policies, the Local Productive Arrangement of Santa Rita do Sapucaí started being structured as of 1985, when the municipal government, understanding the endogenous potential of the city, focused on the development of small enterprises in the electronics segment through the use of policies that allowed the installation of new plants, in addition to supporting existing ones, such as the deferral of taxes, land transfer, payment of rents for a specified time and negotiations with the state government. It was at that time that it started being known as the "Electronic Valley", which stands until today on the identity and logo of the region[5].

The installation of Escola Técnica de Eletrônica (ETE) in 1958, pioneer in Latin America in technical education for electronic, Instituto Nacional de Telecomunicações (Inatel) in 1965, pioneer in the country in higher education for telecommunications, and Faculdade de Administração e Informática (FAI) in 1971, pioneer in higher education for information

[5] Information obtained from interviews with the current municipal manager.

technology, enabled the training of highly qualified and skilled professionals, promoters and inducers of the spontaneous emergence of a productive cluster of technology-based companies.

Located in the South of Minas Gerais and with a small population of approximately 36,150 inhabitants, Santa Rita do Sapucaí has a GDP per capita 50% higher than the state average and has as its main economic driver the concentration of more than 140 technology intensive companies that make up a productive structure with strong interaction and have a high degree of specialization, generating approximately more than 9,000 direct and indirect jobs (SINDVEL, 2009).

The main fields of activity of the companies comprising the LPA of Electronics of Santa Rita do Sapucaí are: telecommunications (22%), electronics (18%), electronic security (12%), automation (11%) and information technology (11%). In the area of telecommunications, the LPA serves 70% of the domestic broadcasting market and is one of the pioneers in digital TV research, production of converters (set-top boxes) and digital signal transmission (IEL, 2007). An important feature of the LPA is the predominance of micro (32%) and small enterprises (47%) that are the result, mostly, of the three technology-based incubators in the city (IEL, 2007).

The LPA is characterized by the cooperation between companies to overcome barriers to technological advancement and take advantage of the benefits of joint marketing actions, purchasing and distribution centers, research, project development and design centers, usually not feasible for a small company. The virtuous cycle of growth generated by the exchange of information and experiences between the LPA companies is led by a professional association - Sindvel[6], affiliated to Fiemg[7], which operates in partnership with educational institutions and other entities, such as IEL[8], SEBRAE and local, state and federal government agents.

Tables 1 and 2 show, respectively, the key information that currently characterize the LPA of Electronics of Santa Rita do Sapucaí and its evolution over the past four years, while the graph in Figure 4 illustrates the growth of LPA in numbers of companies since its origin in 1977 with the installation of the first technology-based company in the city.

Table 1 – The Local Productive Arrangement of Electronics of Santa Rita do Sapucaí

Territorial unit	*Santa Rita do Sapucaí, MG*	*351 km² (1)*
Inhabitants	***36,150 (1)***	
Technology-based companies	Broadcasting, Telecom, Security, Automation, Information Technology, Biomedicine, Electronics and Parts, spare parts and services (2)	141 micro, small and medium enterprises (2)
High school with professional qualification	Electronics, Information Technology, Accounting, Electrical, Telecommunication, Biomedical	1,200 students in three schools: ETE, Colégio Tecnológico and

[6] Union of Industries of Electrical, Electronic and Similar Appliances in the Electronic Valley
[7] Federação das Indústrias de Minas Gerais (Union of Industries of Minas Gerais)
[8] Instituto Euvaldo Lodi (Euvaldo Lodi Institute)

	Equipment, Quality and Administration (2)	Senai (2)
Higher education (classroom)	Telecommunication Engineering, Computer Engineering, Biomedical Engineering, Administration, Information Systems and Pedagogy (2)	2,200 students in two schools: INATEL and FAI (2)
Business Incubators	Municipal Incubator, Inatel Incubator and FAI Incubator (2)	69 graduated students + 27 residents (3)
Jobs	9,500 (2)	
Products	12,000 (2)	
Revenue	R$ 1 billion in 2008 (2)	Forecast growth of 15% in 2009 (2)
Export	U$ 16 million (2)	42 exporting companies (2)
GDP on current prices (2007)	565,328,000 Reais (1)	
GDP per capita (2007)	16,508 Reais (1)	

Sources:

(1) IBGE: http://www.ibge.gov.br/cidadesat/topwindow.htm?1, accessed July 2010
(2) Sindvel (2009)
(3) Data obtained directly from incubators (2010)

Table 2 - Progressive Growth of the LPA of Electronics of Santa Rita do Sapucaí

	2006	*2007*	*2008*	*2009*
Companies	*73*	*107*	*137*	*141*
Jobs	*4,800*	*7,200*	*8,600*	*9,500*
Products	*7,800*	*9,600*	*11,500*	*12,000*
Revenue	*R$ 500 million*	*R$ 780 million*	*R$ 1 billion*	*R$ 1.15 billion*
Exporting Companies	*22*	*36*	*47*	*58*
Product Approvals	*0*	*0*	*14*	*22*
ISO 9001	*6*	*22*	*42*	*42*

Source: Sindvel (2009)

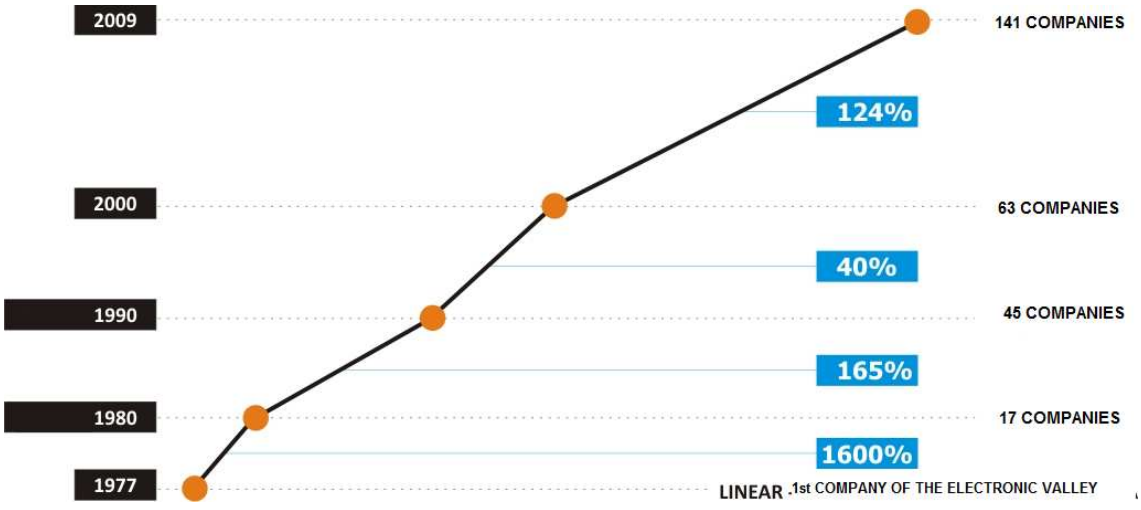

Figure 4 – Evolution of the LPA of Electronics of Santa Rita do Sapucaí
Source: Sindvel, 2009, p.35

Also in relation to the LPA data and evolution, special mention to the sharp increase in the GDP of the city, which was from R$ 277 million (current prices) and R$ 8,500 (per capita) in 2002 to R$ 565 million and R$ 16,500, respectively, in 2007. It corresponds to an increase of almost 100% in only five years[9]. Regarding its stage of development, the LPA of Electronics of Santa Rita do Sapucaí is considered by the government of Minas Gerais as the one that indicates the highest degree of organization (SECTES, 2010), which was classified, according to Sebrae (2010) as a developed LPA, or as defined by RedeSist (2010), it represents a Local Productive and Innovative System (LPIS).

The Innovation Process in the LPA of Electronics of Santa Rita do Sapucaí

Aiming to understand and analyze how innovation occurs in the LPA of Electronics of Santa Rita do Sapucaí, a survey of secondary data was conducted, mainly covering the diagnosis elaborated by Instituto Euvaldo Lodi (IEL) in 2007 and the current records available in government agencies, business incubators, educational institutions and the professional association representing the LPA companies.

The diagnosis of the IEL (2007) was based on extensive research with 82 local companies, as well as additional research conducted with educational institutions and local incubators. In order to systematize the findings of this study, the diagnostic results (IEL, 2007) were used as a starting point for each item analyzed and then supplemented with current information obtained directly from Sindvel managers.

Considering that the study is based on the Triple Helix model (LEYDESDORFF; ETZKOWITZ, 1998), the information is grouped according to three institutional spheres covered therein: university, industry and government.

a) University

- One of the main reasons for the emergence and development of high technology companies in the region is the presence of a number of educational and research institutions. INATEL, FAI and ETE are jointly a great center that generates highly qualified workforce, which is absorbed by the industries of the region and from where the new entrepreneurs of the LPA arise (IEL, 2007).
- The institutions generate a natural development of the local expertise in electrical, mechanical, electronic engineering, information technology and telecommunications, attracting industries and encouraging the professionals to entrepreneurship (IEL, 2007).

[9] **IBGE PIB** ***1999-2002, available at*** ***http://www.ibge.gov.br/home/estatistica/economia/pibmunicipios/2002/tab01.pdf*** ***and*** ***http://www.ibge.gov.br/cidadesat/topwindow.htm?1***

- The graduate students from the institutions, despite the different backgrounds considered, usually enter the LPA companies (IEL, 2007).
- It is worth it to mention the high annual average of projects and researches developed by the local institutions, which reaches 20 per year in some of them. Most of them are focuses on the LPA companies and reach all sizes, with greater attention to micro and medium enterprises (IEL, 2007).
- The projects and research in cooperation with LPA companies usually takes two to three years and, besides being well-regarded by the educational institutions, sometimes they are perceived as an institutional objective (IEL, 2007).
- The main benefits identified are the training of teachers and students through a contact with the industry, integrating theory and practice, and involving them in the reality of technology transfer, allowing their full-time dedication. It also represents new partnerships that allow fundraising for research and development (R&D), the search for new technologies and maintenance of laboratories (IEL, 2007).
- The main instruments or forms for the relationship between these agents are the informal exchange of information and joint R&D projects, in addition to public conferences, consultancies and temporary exchanges of personnel (IEL, 2007).
- The main research lines for the development of projects with LPA companies are electronics, information technology and telecommunications, also with influence from information systems, automation and control engineering, electrical engineering and biomedicine (IEL, 2007).
- The funds for the projects come from funding institutions or, to some extent, from benefit under the Law of Information Technology. To a lesser extent, companies and educational institutions can also invest their own resources to pay for research and projects (IEL, 2007).
- As a result, almost all projects generated products, processes or new technologies, and for half of the institutions, a few patent applications (IEL, 2007).
- As of the end of 2009, the three institutions started being jointly included in the managing and advisory committees of the newly created Center of Excellence in Electronics and Telecommunications, which main mission is to articulate and aggregate the necessary competences for the technological development of the sector, in order to contribute to increase the innovation capacity and qualification of human resources and to promote the competitiveness and sustainability of these strategic sectors (SECTES, 2010).

b) Industry

- The LPA companies of Santa Rita do Sapucaí usually arise from the initiative of entrepreneurs who have studied in their own region. This seems to influence the high

degree of integration among these companies, which in turn stimulates their growth together (IEL, 2007).

- Engaged regarding the electronics industry dynamics, 63% of the companies have implemented some activity of Research, Development & Innovation (RD& I) between 2004 and 2007. In 53% of them, such activities include product and process, while the remaining 47% focused only on the product. For more than 54%, an internal department of RD&I is the main place to implement these activities and another 33% do so within the company without a specific department (IEL, 2007).

- The volume of funds invested in research and development in the same period was also high, as shown in Figure 5. Despite the higher number from companies that invest in innovation, information technology companies are also investing large sums in these activities, followed by electronics and telecommunications, not by chance areas of high innovative capacity in the region (IEL, 2007).

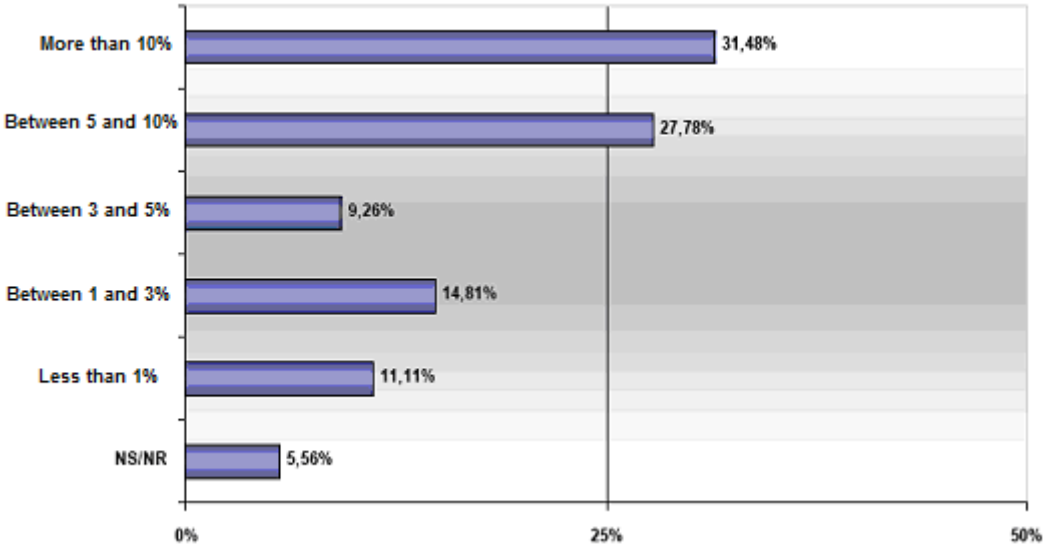

Figure 5 - Average Percentage of turnover invested in R&D between 2004 and 2007
Source: IEL, 2007, p. 50

- Nearly half of the companies that have implemented actions with the purpose to innovate reported the use of some tax benefit, largely related to the ICMS[10] Protocol and benefits provided for in the Law of Information Technology, such as the program Basic Productive Process (those that are connected to the computer market), which offers the reduction of indirect taxes subject to the compliance of the basic rules of industrial procedure and application of funds in R&D (IEL, 2007).

[10] Taxes on goods and services

- The main credit facilities for R&D projects of the LPA are related to institutions or programs focused on the development of micro and small enterprises or related to state programs, such as the Sebraetec and Amitec programs created by IEL Minas, in addition to the research funding agency of the State, Fapemig, which alone has financed projects worth more than 33% of those LPA companies with R&D actions. Agencies and federal development banks such as BNDES[11], CNPq[12] and FINEP[13], and the Development Bank of Minas Gerais - BDMG are also representative: 42.5% of the companies have already used resources from funding agencies (IEL, 2007).

- It is worth mentioning that out of the nearly 150 projects presented to funding institutions by companies participating in the research over the past three years, more 67% were approved for funding (IEL, 2007).

- From 2004 to 2007, partnerships with local educational institutions resulted in nearly 80 projects (IEL, 2007).

- The main resources of educational institutions used by the companies are development laboratories (IEL, 2007).

- The partnership with educational institutions seems to maintain a direct relationship with the presentation of research and development projects to agencies, banks and funding programs, as many of these projects arise from companies seeking partnerships with local institutions (IEL, 2007).

- More than 84% of LPA companies have demonstrated that they care about the training of their employees in several ways. More than 50% of the companies say they invest up to 1% of their annual revenue in personnel training, and that investments above 0.5% are the most common (IEL, 2007).

- The development of new products is one of the characteristics of LPA companies, which applied for 12 patents only in 2006. All companies that have registered patents, an indicator of the ability to innovate, stated that they invest in training (IEL, 2007).

- The concern for quality started being understood by the companies as a criterion for competitiveness. The establishment of a System for Quality Assurance is one of the actions developed in an LPA project that arose from the partnership between Sindvel and other agents, such as IEL and Sebrae-MG (IEL, 2007).

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[11] *Brazilian Development Bank*

[12] *The National Council for Scientific and Technological Development*

[13] *The Brazilian Innovation Agency*

- The cooperation among the companies to overcome barriers to technological advance and take advantage of the benefit of actions such as marketing, purchasing and distribution centers, research and development centers of projects and design, among others, often not feasible for the individual company is led by Sindvel, the professional association that represents LPA companies that, with the support of several local, state and federal agents also develops a range of projects and actions towards the innovation and development of companies, such as: Industrial Fair of the Electronics Valley, national and international trade missions, local, national and international rounds of negotiations, certifications and approvals of products, integrated sector project for the internationalization of the companies, participation in national and international fairs, development and consolidation of the trademark "Electronics Valley" , among others (Sindvel, 2009).

- The companies evaluate as positive the leadership provided by Sindvel, especially with regard to the involvement of local players and the constant search for funding for the companies, already supported by the real growth of the center (IEL, 2007).

c) Government

At the governmental level, the process of innovation that occurred in the LPA is directly and indirectly affected by the state, federal and municipal public policies, with a predominance of state policies, since the 2003/2010 government prioritized the areas of science, technology, innovation and higher education, considering the innovation issue as a strategy to transform the State of Minas Gerais into a leader in the knowledge economy (SECTES, 2010). It is worth it to mention that the representation of the state and municipal governments in the LPA governance, which act directly on the advisory and deliberative councils with representatives from the State and Municipal Departments of Science and Technology.

Below, we present the main aspects identified in recent years related to the participation of the federal, state and municipal governments in the innovation of the LPA of Electronics of Santa Rita do Sapucaí.

State Government

- Promulgation, in 2006, of Law No. 16.296, which structures the state policy of support for Local Productive Arrangements and the granting of approval of ICMS on import of raw materials and sale of finished products (IEL, 2007).
- Creation, in 2006, of the Innovation System of Minas Gerais of which the Structuring Project of Regional Industrial Development is part, which includes the Local Productive Arrangements, Centers for Excellence and Innovation Centers. The LPA of Electronics of Santa Rita do Sapucaí is one of the four LPA of Minas

Gerais prioritized by the project, as specified in the Integrated Development Plan of Minas Gerais 2007-2023 (SECTES, 2010).

- Within the LPA Structuring Project, Santa Rita do Sapucaí received funds totaling approximately R$ 16 million for the period 2008 to 2010 specifically to develop a set of eight actions performed and managed by the institutions that comprise the LPA governance - Sindvel, FAI, Inatel and ETE (SECTES, 2010).
- The actions defined within the scope of the LPA Structuring Project for the period covered were outlined and discussed by the governance represented by the education institutions, Sindvel, state government, municipal government, Sebrae and IEL/Fiemg. Among these actions, it is worth mentioning the performance of annual calls of Fapemig[14] for innovation projects of the LPA of Electronics and the implementation and operationalization of the Intelligence Bureau, the Center of Excellence in Embedded Software and the Design House (SECTES, 2010).
- Also part of the Innovation System of Minas Gerais and within the context of the Structuring of Regional Industrial Development, Santa Rita do Sapucaí received investments for the implementation of the Center of Excellence of Electronics and Telecommunications, being the only municipality in Minas Gerais characterized as LPA and Center of Excellence (SECTES, 2010).
- Under the Structuring Project - Network of Technological Innovation, the LPA received investments of R$ 2.5 million for the readjustment of the Municipal Incubator, which will have a new headquarters and its capacity increased by 43%, thus incubating 20 technology-based projects (SECTES, 2010).
- The LPA is among the seven arrangements of Minas Gerais covered with funds from Inter-American Development Bank (IDB) of US$ 3 million for investments in innovation and technology development as of 2010 (SINDVEL, 2009).
- The government has also supported the sector and benefits the region through actions and incentives, such as the Induction Program to Induce Industrial Modernization - Proim and the Program of Support to Companies of Electronics, Information Technology and Telecommunications - Proe-Eletrônica, with funds from Fundiest (Fund for the development of strategic industries), in addition to the actions of the Technology Network of Minas Gerais for the competitive replacement of imports (IEL, 2007).
- During the period from 2007 to 2009, a total of 57 different projects for the development of innovative products have been financed with funds from Fapemig, in different types of calls, totaling approximately R$ 11 million in non-reimbursable funds[15].

[14] Fundação de Amparo à Pesquisa do Estado de Minas Gerais (Research Support Agency of Minas Gerais)

[15] Data gathered from documents provided by Sindvel, Incubators and Fapemig.

Municipal Government

- The Municipal Program of Advanced Incubation of Technology-Based Companies – PROINTEC and the Municipal Incubator of Companies "Sinhá Moreira" - IME, were created in 1998 by Law 3.043/98 and their actions are made possible through partnerships with government and academic institutions (PROINTEC, 2010).
- The Advisory Council of PROINTEC consists of the Director of the Municipal Incubation Program, the Municipal Secretary of Science, Technology and Innovation and representatives of academic institutions of the LPA (PROINTEC, 2010).
- The average number of projects and research developed by the incubators varies according to the legal nature and duration, but it is usually three per year. In the incubators of Santa Rita, 20% to 30% of these projects and research are focused on the LPA companies, in general to micro and small enterprises, with little participation of medium enterprises and duration lower than six months. The development of projects and research is largely financed by funding institutions (from 75% to 100%) and to a lesser extent, by the manager, with the incubator's own resources, by universities or clients, in this order (IEL, 2007).
- In the period from 2007 to 2009, twenty-two companies incubated in the Municipal Incubator received non-reimbursable funds of R$ 2.3 million for the development of innovation projects financed by Fapemig, Finep and Sebrae[16] (PROINTEC, 2010).
- Since 2005, there is a Municipal Science and Technology Department in the organizational structure that is responsible for the incubation program and other actions related to the technological innovation of the LPA (PROINTEC, 2010).

Federal Government

- The federal government's involvement in the innovation of the LPA is associated mainly with the policies of Science, Technology and Innovation established for the country, as well as the development policies, particularly the Productive Development Policy (PDP) which points out the priority areas and strategic sectors for the development of the country (MCT, 2010).
- Laws such as the Law of Innovation, Law of Information Technology and Law of Goods, which comprise the national innovation policy, are also important components of the innovation process, providing sustainability for more direct actions undertaken by the state government and educational institutions (MCT, 2010).

[16] Information obtained in the internal records of the Incubator

- More directly, we can highlight the involvement of institutions such as Finep, CNPq, Sebrae and Senai[17] in the support to the scientific research and technological development that have occurred in companies and institutions of the LPA (SINDVEL, 2009).
- From 2007 to 2009, only economic subsidy calls for innovation of Finep contemplated 19 LPA companies with total non-reimbursable funds of approximately R$ 30 million (SINDVEL, 2009).
- The FINEP/PRIME Call, First Innovative Company, contemplated 41 LPA companies in 2009, and more than half of them were incubated companies (SINDVEL, 2009).
- We shall also point out Fundo de Investimentos Rotatec [Investment Fund] established with funds from Finep (R$ 4.8 million), Fapemig (R$ 4 million) and private sector (R$ 3.2 million) for investments in innovative projects of the LPA (SINDVEL , 2009).

Conclusions and Final Considerations

Considering the concepts related to the Triple Helix model presented above and the information obtained on the participation of the three institutional spheres - university, industry and government in the innovation process that occurred in the LPA of Electronics of Santa Rita do Sapucaí, it is clear that the interactions identified indicate the existence of a Triple Helix, which can be represented by Figure 6. It can be seen that the inter-institutional activities identified are characterized mainly by the Incubators, the Center of Excellence in Electronics and Telecommunications, the Intelligence, Development and Innovation Bureau, and by the APL governance itself.

[17] *National Service of Industrial Education*

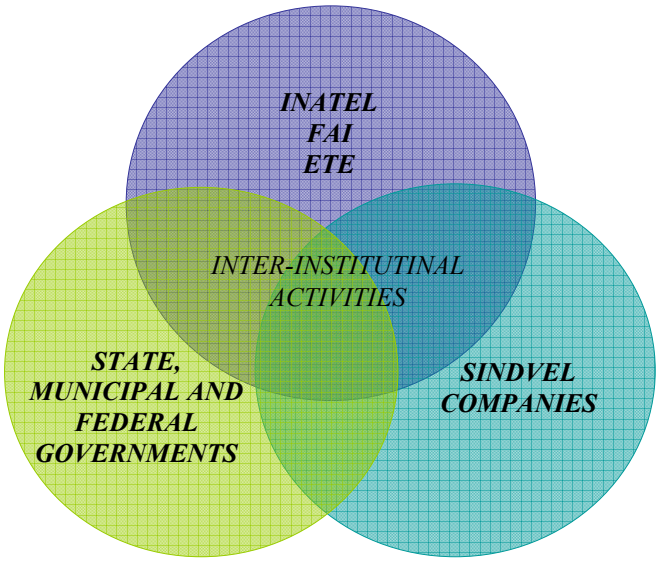

Figure 6 – Triple Helix of the LPA of Electronics of Santa Rita do Sapucaí
Source: adapted from Etzkowitz and Leydesdorff, 2000, p. 111

By relating each one of the aspects inherent to the Triple Helix model mentioned in the literature with the reality identified in the LPA of Electronics of Santa Rita do Sapucaí, as shown in Table 3, we could find the existence of the Triple Helix model in the innovative process that occurs in the LPA. In this context, besides promoting innovation, interactive networks between companies, universities and government also create opportunities for knowledge sharing, in order to establish an entrepreneurial culture and the guidance of scientific research and public policies more towards the reality of a fast changing market.

Table 3 - The Triple Helix in the Electronics LPA - comparison theory x practice

CONCEPTUAL MODEL	ELECTRONICS LPA
More prominent role of the university in innovation (ETZKOWITZ; KLOFSTEN, 2005).	• One of the main reasons for the emergence and development of high technology companies in the region is the presence of a number of educational and research institutions. • The institutions generate a natural development of the local expertise in electrical, mechanical, electronic engineering, information technology and telecommunications, attracting industries and encouraging the professionals to entrepreneurship (IEL, 2007). • From 2004 to 2007, partnerships with local educational institutions resulted in nearly 80 projects. • All actions invested by the government in the LPA involve at least one of the educational institutions. • Education institutions participate in the LPA governance, the Advisory Council of the Center of Excellence and in the Municipal Incubator of Companies.

Table 3 - The Triple Helix in the Electronics LPA - comparison theory x practice (cont.)

CONCEPTUAL MODEL	ELECTRONICS LPA
Collaborative relationships between the three institutional spheres (ETZKOWITZ; KLOFSTEN, 2005).	• The LPA is characterized by the cooperation between companies to overcome barriers to technological advance and take advantages of the benefits of joint actions. • The virtuous cycle of growth generated by the exchange of information and experiences between the companies of the LPA is led by a professional association – Sindvel which operates in partnership with educational institutions and other entities, such as IEL, SEBRAE and local, state and federal government agents. • Representatives of educational institutions, state and municipal government and companies (Sindvel) jointly comprise the LPA governance and the Center of Excellence. • The projects and investments determined for the LPA are decided jointly by the three institutional spheres (such as the LPA Structuring Project and IDB Project).
They form a mutually beneficial relationship among them (ETZKOWITZ; ZHOU, 2006).	• The companies enjoy the benefits associated with actions such as marketing, purchasing and distribution centers, research centers and project development and design, etc. • The main benefits for the institutions are the training of teachers and students, integration between theory and practice, involving them in the reality of technology transfer, allowing their full-time dedication. It also represents new partnerships that allow fundraising for research and development (R&D), the search for new technologies and maintenance of laboratories (IEL, 2007). • LPA growth well above the national average: 94% increase in GDP per capita and 104% of GDP at current prices in five years (2002-2007). • Increase in only three years (2006 to 2009) of 54% in revenues, 98% in the employment generated and 93% in the number of LPA companies. • Companies directly benefit from government investments of R$ 40 million non-reimbursable funds in only three years (2007-2009).
Each sphere is increasingly able to assume the role of the other with internal transformation of each of the helices. (LEYDESDORFF; ETZKOWITZ, 1998, LEYDESDORFF; ETZKOWITZ, 1996, ETZKOWITZ et al, 2000 and ETZKOWITZ, 2000).	• Entrepreneurial role of the two universities: education program, incubators and technology fairs. • Performance of universities on corporate projects, market studies, competitive intelligence, consultancy and training. • Companies invest in personnel training, include teachers and doctors in the staff and participate in projects shared with other companies and educational institutions. • Business professionals present papers at conferences and publish articles in scientific journals. • Creation of corporate structures within universities: Intelligence Bureau at FAI and the ICC at Inatel. • Companies develop strategic alliances to develop innovative projects in the LPA. • State Government participates actively and directly in the elaboration of projects.

Table 3 - The Triple Helix in the Electronics LPA - comparison theory x practice (cont.)

CONCEPTUAL MODEL	ELECTRONICS LPA
Creation of a new overlay of trilateral networks and organizations from the interaction among the three helices, serving both to institutionalize and reproduce the interface, and to stimulate organizational creativity and regional cohesion. (ETZKOWITZ et al, 2000 and ETZKOWITZ, 2000).	• Management committee of LPA • Center of Excellence of Electronics and Telecommunications • Intelligence, Development and Innovation Bureau of the LPA
Recursive effect of these inter-institutional networks representing academia, company and government, both on their originating spheres and the larger society. (ETZKOWITZ et al, 2000 and ETZKOWITZ, 2000).	• Growth and strengthening of educational institutions. • Growth and strengthening of companies. • Development of the city, region and state. • Generation of jobs and income.

Source: summary of data collected from the institutions that comprise the LPA, presented in the previous chapter

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This finding is in line with the perspective of a knowledge-based economy, in which the university becomes a key element of the innovation system, both as a provider of human capital as a place for the emergence of new companies. In the case studied, the source and perhaps the main reason for the success of the Electronics LPA of Santa Rita do Sapucaí, is in the existence of two entrepreneurial universities that, by playing some of the roles of the industry and government, represent the core institution of an innovative region, as previously advocated in the literature (ETZKOWITZ; KLOFSTEN, 2005). Moreover, one can see that the three institutional spheres (public, private and academic) are intertwined in a spiral of links that emerge in various stages of industrial innovation and policy-making.

This paper gives opportunities for new research studies in other LPA and innovative regions, or even for future insights and approaches in the same LPA studied, covering, for example, the public policies involved and the existing indicators of innovation and competitiveness.

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