

SECTORAL INNOVATION SYSTEM OF THE ELECTRONICS SECTOR IN BRAZIL

ELIANE FERNANDES PIETROVSKI, ME.
Federal University of Technology – Paraná – UTFPR – Brazil
eliane@ufpr.edu.br

DÁLCIO ROBERTO DOS REIS, Dr.
Positivo University – UP- Brazil
dalcio.reis@gmail.com

SIEGLINDE KINDL DA CUNHA, Dra.
Positivo University – UP- Brazil
skcunha21@gmail.com

JOÃO LUIZ KOVALESKI, Dr.
Federal University of Technology – Paraná – UTFPR – Brazil
kovalesski@utfpr.edu.br

VANESSA ISHIKAWA RASOTO, Dra.
Federal University of Technology – Paraná – UTFPR – Brazil
vrasoto@gmail.com

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ABSTRACT

Innovation presents itself as an important strategy and a challenge for companies that introduce new technologies products, services and management processes. This challenge has as guidelines the of enterprises in the insertion competitive world and the strategy entails the processes that lead to the development of economic and social structures supported by sectoral systems of innovation. The present study aims to characterize the structure of sectoral innovation system of the electronics complex in Brazil. With regard to objectives, the research is exploratory and descriptive. As for the technical procedures, the research is considered to be document being the data gathering secondary and the analysis procedure predominantly qualitative. The point out towards a scenario technological diversify between sectors and product lines, wich have made possible to identify and explain the technological opportunities and also the limitations of the electronics companies in Brazil, which also helped to define their technological trajectory and business market. Therefore, the present study addresses some aspects under the theoretical opinions in the field of innovation and presents the structure of a sectoral innovation system for the electronics sector.

Key words: Strategy; Technological Innovation, Sectoral System, Electronics Sector.

INTRODUCTION

Organizations today face profound structural changes, both in the economic and in the social context. In this scenario, the emphasis must be given to innovation as an important instrument to trigger the necessary technological changes that lead to the country's economic development process.

The bivalent concept of technological change is presented to identify the subject innovation with technological progress and to consider innovation as the engine that triggers economic development, regarding the production of new goods and the use of methods to produce these goods (Schumpeter, 2008).

Nelson and Winter (2000) highlight the uncertainty of innovation processes due to the complex structure and the evolutionary trajectory. Innovation is presented as a dynamic character, as an element that feeds and influences the process. In this sense, referring to the dynamic nature of the organizational structure appears as a result of innovations that have been introduced in the past, characterizing as a result of environment of the system evolution. They point out that the studies are disjointed and require bonds of projects of creation and diffusion of technologies.

Therefore, the literatures highlight that innovation is an important strategy for economic and social structures of companies in general, supported by sectoral innovation systems. In this sense, the present study intends to make an analysis of Brazilian companies in the electronics sector in order to answer the problem question that guides this study: What are the characteristics of the structure of Sectoral Innovation System of the electronics sector in Brazil?

Thus, it is proposed objectives for this research:

General objective:

Characterize the structure of the innovation sectoral system of electronics complex in Brazil.

Specific Objectives:

- I. Introduce the training of electrical and electronics sector in Brazil;
- II. Describe the technological trajectory of the innovation system of the electronics sector in Brazil;
- III. Identify key actors and institutions that guide the innovation system of the electronics sector in Brazil;
- IV. Describe the public policy of the innovation system of electronics sector in Brazil.

The research delimitation for the electronics sector is justified because it is an industrial axis in the Brazilian scenario. As a practical contribution of the article highlights the electronics sector as a comprehensive well sectoral system and representativeness on product, service and process innovation development. As a theoretical contribution the justification is based in the argument that the sectoral patterns of innovation contribute to the institutional design of intersectoral differences in technological trajectories of the Brazilian industry complex.

The paper is structured as follows: section 2 deals with the general and conceptual approach on Innovation and Innovation Systems; Section 3 deals with the methodology used to answer the question of the proposed research; Section 4 presents the analysis of data from the electronics sector researched; Section 5 presents the conclusions about the research in consistent with the general and specific objectives and, finally, the references used in the study.

THEORETICAL FRAMEWORK

This chapter will discussed the following themes: innovation and innovation systems which will serve as the theoretical basis for this research. This study was based on the literature of institutionalists

authors highlighting the National Systems of Innovation and also presents the concepts of the relationship between markets, institutions, and innovation systems.

Innovation

The studies of Nelson and Winter (2000) marked an important benchmark for the analysis of innovation theory, noting that the process of technological change occurs dynamically. Present a theoretical framework for understanding the relationship between innovation and economy and so, start from two basic premises, one supported in technological advancement, which formed the basis of human progress from the past and the other is the proposition that individuals hold knowledge that establishes the direction and priority of goals to lead the results of actions in the future.

In this technological change scenario stands out the competition, pointed out in the Schumpeter (2008) model, which determines the winners and losers in this dynamic. Growth and utilization of opportunity will be given to some at the detriment of others. The different patterns of growth, evidenced by the competitiveness, will be appropriate in the process of changes in routine, regarded as the genetic background of the phenomenon, known as mutation and the environment is therefore known as the selection mechanism, like the Biology study (Nelson, 2006).

Corazza and Fracalanza (2004) present a theoretical construction of technical and economic changes, which were broadcasted from the late 1970s by neo-Schumpeterian economists. On the one hand, the analyzes made by the neoclassicals rested upon concepts of Newtonian mechanics (laws, movements, strength, balance), approaches Shumpeter supported on the vision of Biological Sciences, with the basic analogies according to the theory of evolution.

In the approach regarding the innovation of the technological advances are related the so called technological requirements which drive the development of certain technologies, regarding the products improvement among others. These factors indicate the projects of research and development R&D that are feasible and have value in their conditions of demand and costs (Rosenberg, 1972).

When dealing with to technological innovation is evident the introduction of new technology and products or significant improvements in existing products and processes. It is considered that a technological product or process has been implemented if it has been introduced on the market (product innovation) or used in the production process (process innovation). Technological product or process innovations involve a series of scientific, technological, organizational, financial and commercial activities. "The innovative company is one that introduced products or technologically new or significantly improved processes in a reference period" (OECD, Oslo Manual, 1996, p.35).

Innovation system

The National Innovation Systems comprise "all social, economic, political, institutional, organizational factors, etc., responsible for generating, by use, by diffusion, by absorption, or by modifying the import of knowledge and/or innovations "(Strachman, Deus, 2005, p 593). Thus, the policy as a tool organizes and conducts actions, defining and mapping the technological trajectory of a nation, as a form of institution.

Studies Kastle et al (2009) show that innovation systems cause economic development, but are often not seen as evolution. The structure of the innovation system is mapped, focusing on the

identification and description, and tend to move away from questions of how innovation systems can change internally in the organization, or even how agents interact with the innovation system. In this sense prevail an analytical notion, implicit as a balance for the innovation system, in which all agents are fully adapted, and there is no evolution of innovative technologies or rules established in this scenario.

While the formal study of innovation systems is a relatively recent phenomenon, the intellectual roots of this research are profound. List (1856) which was the first to discuss in depth the importance of innovation and knowledge for the economic growth of countries. The main theorist who became a reference for the formulation of the concept of National Innovation System (NIS) was Joseph Schumpeter (1911) that highlighted the importance of innovation as the engine of capitalism, analyzing capitalism as something in evolution, which is not static and that structural changes are endogenous to the economic system. Modern literatures, centered around SNI were published in early 1990: the first by Lundvall (1992) being conceptualized innovation as learning; Nelson (1993), who shows the SNI with a descriptive definition, detailed in R&D and organizational structures; and Freeman (1994) that shows the importance of ideas about national economic development policies (Smith, 2000).

In this context of innovation policy, Smith (2000) analyzes the resulting implications as a systemic phenomenon: provides an overview of conceptual approaches used in recent literature on innovation systems; analyzes the learning and technological knowledge at the enterprise level, and explores the ways in which different theoretical approaches affect the understanding of innovation processes; discusses the political problems arising from this broad field of study, focusing on two issues: the rationale for intervention and policy skills and knowledge bases.

In terms of the literature on innovation approach, confronting the industry approach and the industrial economy, we present the differences between the sectors in terms of technologies developed in the countries and even the inclusion of production, beyond innovation. Thus, Malerba (2002) considers that a sectoral system of innovation consists of a set of heterogeneous agents, in the context of the market and its non-market interactions for both the creation, adoption and use of technologies such as the creation, production and use of products of a particular industry.

The agents composing the sectoral system are individuals and organizations, including organizations of lower or higher levels of aggregation. They have characteristics in behavior, skills, structures and specific learning processes. Interact in a non-market way through various processes and also in dealing with the market and their interactions are shaped by institutions. A sectoral system changes over time through processes of coevolution, as it is considered a dynamic system (Malerba, 2002).

One of the studies on the construction of taxonomies of sectoral systems, they group the sectoral systems in various dimensions, specifying the sectoral patterns of innovative activities. The Taxonomy of Pavitt (1984) is an important contribution to comprehensively understand the connections between the strategies of firms and the strategies of Research and Development (R&D), in the patterns of innovative activities. Therefore, these taxonomies should complement previous studies, which provide progress when it comes to understanding the differences in all sectors.

METHODOLOGY

The methodology to be employed for the realization of this theoretical-methodological research involves a literature search of concepts about innovation.

In this approach, this paper tries to examine the innovation system of the electronics sector through its innovative approach in the Brazilian industry, in order to answer the problem question that guides this work by identifying the characteristics of the structure of Sectoral Innovation System in Electrical and Electronic Industry Brazil.

Therefore, they are research questions for the identification and analysis of how it was developed and if it structure the sectoral system of innovation in the electronics sector in Brazil:

- I. What are the main actors that guide innovation system of the electronics sector in Brazil?
- II. What is the coevolution between these actors in the innovation system of the electronics sector in Brazil?
- III. What is the infrastructure of the innovation system of the electronics sector in Brazil?
- IV. What is the economic, social, technological and institutional system of the innovation system of the electronics sector in Brazil?
- V. What are the policies for the innovation system of the electronics sector in Brazil?

As to the objectives, the present paper is an exploratory and descriptive research with a cross-cut. Regarding the technical procedures, the research is considered documentary, and data were collected on technical articles, economic reports about the electronics sector in Brazil. Therefore, the source of data collection is considered as secondary and the analysis procedure is predominantly qualitative approach.

DATA ANALYSIS

This chapter presents the data from the electronics sector in Brazil, regarding: training sector, the technological trajectories of the innovation system, the main actors of the innovation system and the public policies of the sectoral system of innovation in the industry.

Formation of the electronics sector in Brazil

In Brazil the formation of the electronics sector started from the 50s as a result of the rapid growth of the internal market in consumer electronics area, which required the manufacture of some components, such as transistors and diodes in the local industry (Hauser et al, 2007).

The electronics complex comprises several industrial sectors that are intertwined, because they have in common the same basic technology, the microelectronics, however such segments have their own characteristics and dynamics. Thus, the Brazilian electronics complex involves the following segments: consumer electronics, information technology products (hardware and software), telecommunications equipment and electronic components (Gutierrez, Alexandre, BNDES, 2003).

The sectors of electrical and electronic components of consumption are predominantly located in Sao Paulo and Manaus Free Zone (MFZ). As a strategy to promote regional development the MFZ was created, which aims at promoting productive and social integration of the Amazon region, as

well as to ensure national sovereignty on the borders of the country (Ferigotti, 2005; Hauser et al, 2007).

Through documents and reports may also be observed that since the formation of the sector companies have a strategic vision of innovation with the creation of centers of research and development, but are directed more towards the adoption of innovations than incremental changes radical in its products and processes.

Technological trajectories of the innovation system of the electronics sector in Brazil represent a set of solutions adopted for the industrial production adopted by a firm or group of firms. They are shaped by technical, productive, scientific or economic determinants, and bring with them a load of historical conditions (path dependence), which, at times, come to prevent the most efficient technology is the dominant technology (Saviotti, Metcalfe, 1984).

Pavitt's studies (1984) present a neo-shumpeteriana, in this approach line of technological trajectories and their sectoral taxonomy presents concepts in the evolutionary chain and also leads to the concepts of technology push versus demand pull. The Pavitt taxonomy is an important contribution to widely comprehend the connections between the companies strategies and R&D strategies. The study refers to the large industrial companies in their trajectories of technological change, as the sources of technology, customer requirements in these technologies and how these technologies are appropriate. Technological trajectories between sectors are defined by similar processes of companies which determines the grouping of industrial sectors into categories.

In this approach the electronics sector is related to the category of science-based industries because they are inductors of technological opportunities and are involved with R&D. Innovations from the electronics sector lead to growth in accelerated form of respective companies. In this category, the technological diversification leads to innovations in both products and processes and the protection of intellectual results deriving from these innovations include the patents and know-how (Pavitt, 1984).

The Brazilian Institute of Geography and Statistics (IBGE), with support from the Ministry of Science, Technology and Innovation and the Financier of Studies and Projects (MCTI / FINEP), publishes every three years, the Research of Technological Innovation (Pintec), with the goal of providing information for the indicators construction of innovation activities from Brazilian companies. The research analyzes the Brazilian industrial context of technological innovation through the sources of innovation, forms of knowledge and learning. Presents an overview with a focus of technological trajectory, the types of innovative results and the characteristics of structure and performance of Brazilian industries.

The Pintec 2011 report, corresponding to the period 2009-2011, shows that of the 128.699 companies, 45.950 companies have implemented new products or process or significantly improved processes. Based on the industry it is observed that there was a decrease compared to 2008 PINTEC because 38.1% of the companies have innovated and in the current research the innovation rate corresponds to 35.6% (IBGE, 2011).

Table 1 shows the percentage of the companies that declare innovate in the referred reports Pintec 2008 and 2011, respectively.

Tabela 1 Percentual companies that innovated

	PiNTEc 2008 Períod 2006-2008	PiNTEc 2011 Períod 2009-2011
Percent of companies that innovated	38,1%	35,6%

Source: Reports IBGE 2008 e 2011

Considering the data, Carvalho et al (2011) assert that most companies declare innovating internally and not globally. What prevails, so, that innovation is represented by the purchase of machinery or equipment in your production environment. In this sense, the authors recognize, according to the National Confederation of Industry (CNI, 2009), the attempts of companies, but also recognize that the effort is insufficient, given that the innovation rate is still low in the domestic market and few companies innovate to the world market.

The results indicate the need for automakers companies of electronic products to invest more in the use of information technology to expand the integration of processes, plan and develop products, integrating customers and suppliers to expand the adoption of management practices in the supply chain (ABINEE, 2014).

Main actors of the innovation system of the electronics sector in Brazil

Companies in the electronics sector perform well consolidated activities, particularly with the products development such as marketing focus, also acting with other strategic aspects such as the creation of new markets and businesses, partnerships and joint venture, obtaining, in this way, the global competitive leadership. This technological segment is strongly favored by the innovation and the companies from the electronics sector do not operate in isolation, given the complexity of the processes inherent in the industry.

In that sense, necessary to make the articulation of the processes in the sector with innovation agents so there is a synergy between the actors and the innovation determinants. The actors and these factors are represented, respectively: by the government - laws and public policies articulated among themselves; with higher education institutions and centers of research and development - infrastructure, laboratories, teachers; and other organizations that support these processes and interact with companies.

The action of the federal government as an agent of this innovation process, which contributes the electronics sector in Brazil is represented by the Institution of Industrial, Technological and Foreign Trade (PITCE) and the National Microelectronics Program (PNM), coordinated, respectively, by the Ministry of Development, Industry and Foreign Trade (MDIC) and the Ministry of Science and Technology (MCTI), aiming to seek to increase production efficiency and innovativeness of Brazilian companies and expanding exports (MDIC and MCTI, 2014).

Between representatives organizations in the sector, is the Brazilian Association of Electrical and Electronics Industry (ABINEE, 2014) with its efforts to strengthen and consolidate the electronics complex in Brazil, participating in thematic forums, meetings with government officials and promoting seminars, debates, sectoral meetings and events of national and international scope,

contributing to a discussion of the challenges, the revitalization and development of the electronics sector.

Besides these actors and their activity focus, represented by the government, universities, research centers and organizations linked to the sector, other factors directly impact innovative processes such as the spread of the culture of innovation in the country and the strong synergy between these actors and agents that support innovation.

Political, technological and economic changes in recent decades have become the technological capacity of the country a central point of its competitiveness in the global economy. In this approach, the context of innovation policies in developing countries, especially when it comes to public policy must be structured to occur the interaction between the research and the experimentation (Chaminade et al, 2009).

Gadelha (2001) presents an approach to industrial policy, a neo-Schumpeterian view, situating this policy in the context of national economic development policies. Presents the considerations on industrial policy to explicit the methodological and theoretical aspects of the vision presented, as well as their principal developments:

- a. Denial of the benchmark market failures leading to the hegemonic view justifying state action. However, economic theory presents the notion that market failures arise from the assumption that the market generates efficient governments and public action is justified only by anomalous situations.
- b. Competition as the central theory because it is considered that the business strategies of innovation are formulated, selecting schemes and technological trajectories, in order to stimulate or restrict the actions in the competitive space.
- c. Industrial policy is conditioned by the economic structure and there are evolutionary innovation patterns that are specific and common to different sectors that make up these industrial structures.
- d. Evolutionary industrial policy should constitute a locus of articulation from the state, which must be committed to change along with the ability to strategically analyze progress and to promote an environment conducive to new processes with the interests of innovation and structural transformation of society.

Chaminade et al (2009) find that one of the biggest challenges for the future are the ones faced by politicians when it comes to conceptualize emerging innovation systems. In this approach it is considered that the elements of the system may be there, but missing the interactions between organizations and that some features may be missing and also that resources can be where there are no solutions which entail the development.

The report by Edler et al (2013) presents the key findings and evidence on the effectiveness of innovation policy. This report has two objectives to fulfill: treating the effectiveness and impacts of measures taken in relation to support for innovation; present state of evidence and its production on the effectiveness of innovation policies, considering the evaluation methods, approaches and gaps to provide a more appropriate policy implementation design as well as the production of evidence to support future policy guidelines innovation.

In this aspect, we present a well-established set of logical beyond supply and demand policy. The underlying logic in most instruments is often not explicit in politic schemes, just as is the analysis of specific bottlenecks and opportunities. The results are emphasized the effects of innovation policies, as well as the various programs presented variations in the domains of policy in specific areas (Edler et al, 2013).

Ferigotti and Cunha (2008) state that various policies, government actions and private initiatives were important in the formation of certain sectors of activity, including the development of the electronics sector in Brazil. A new industrial policy focused on microelectronics and software, was launched in 2008, aiming to stimulate innovation and promote scientific and technological advance and the main challenges to raise the innovation capacity and strengthen micro and small enterprises (MSEs).

Some actions can be identified as initiatives of the Brazilian government for the electronics sector, which has selective character, referring to the promotion of incentives as the Manaus Free Trade Zone and subsidies through the Informatics Law (Laws 8248 / 91 10.176 / 01 and 11.077 / 04), which grants tax incentives to companies in the technology sector (hardware and automation), investing in R&D. However, what effectively verifies is that these policies were not always continuous and developed for a long term, committed in a way, that arise emerging segments of the electronics complex (Hauser et al, 2007).

Edler et al (2013) point out that are required more reviews to establish the interaction between innovation policies. They cite the models as innovation agencies or domain-based and policy support innovation agencies to develop strategies on the topic. They also emphasize that politicians and evaluators should pay attention on the impacts of policy instruments for broader innovation by creating multiple programs, as well as their interaction with other instruments, such as the fiscal aspects, human capital and other resources.

When it comes to industrial and technological policy, Ferigotti and Cunha (2008) state that they represent a set of activities promoted by the government which presupposes raising the level of companies technological innovation or the purpose of creating innovative companies, but not restricted only to the instruments of fiscal incentives, it should be comprehensive and form a conjunction of integrated policies that lead the industry to higher levels of productivity and competitiveness, combining learning mechanisms between companies and agents to support innovation. In this approach, the policy is therefore very important for the developing country to tread the paths of linked innovation research.

CONCLUSIONS

This study searched to characterize the structure, based on the complex electronics in Brazil, within the sectoral system of innovation, and presents the context of public policies for the sector. Accordingly, the specific aims to characterize the innovation system in the sector, were all met.

The first specific objective: this was answered by presenting the formation of the electronics sector in Brazil and in the electronics industry consumption, which is the oldest segment of the electronics complex in Brazil, there is some technological dependence and a limitation on R&D and other strategic areas since its formation.

The second specific objective: it was contemplated to describe the trajectory of technological innovation system in the electronics sector in Brazil, presenting the scenario of industries such as the electronics industry intensive in capital and technology and its slow process of disintegration and its shortcomings until the resumption of the innovation process, configuring itself as a dynamic sector with significant technological standards.

The third specific objective: identified the main actors and institutions that drive the innovation system of the electronics sector in Brazil, with their efforts and strategies to strengthen and consolidate the electronics complex in the country.

The fourth specific objective: it was described the industrial policies of the innovation system of the electronics sector in Brazil, presenting an overview of Brazil, particularly in view of the sector complexity and characteristics, which also brings in its structure, small businesses and medium-sized technology-based. Therefore, it is emphasized that the results of industrial policies to stimulate innovation has not reached all sectors of Brazilian industry, in particular the electronics sector, in view of the diversity of sectoral patterns of innovation with the characteristics that present themselves. Thus, the research results indicate a scenario of technological diversification among product lines and sectors.

In this approach, the study enabled to identify and explain the technological opportunities and the limitations under which the companies of the electronics sector situated in Brazil define its path of market and business. In the approach of the present study we attempted to highlight some aspects of theoretical vision in the field of innovation and suggests direct and consolidate the construction of an effective framework for sectoral systems of innovations.

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