

Environmentally sustainable innovation process in Industrial Clusters: the Brazilian case

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Abstract

This paper investigates the relationship of technological innovation tools with the development configuration of clusters in Brazil. We use methodological approach which involves literature review and analysis of examples that encourage understanding. We focus on studies of technological tools and on the importance of the maturity degree to the development of innovation as an analysis method, as well as references of the development of industrial ecosystems, based on the principles of industrial ecology. Our theoretical analysis is divided into two axis of application. At the first one, there is a formation of a cooperation network, where the innovation tools tend to spread and consolidated. In the second axis we explain our theory to strengthen the environmentally sustainable development of the cluster. The results are confirmed using the analysis and discussion of both axis, highlighted through the theoretical-conceptual proposal for the development of innovation tools in clusters.

Keywords: Clusters. Innovation. Economic Development. Regional Development. Competitiveness.

1. Introduction

The innovation process when continuously performed, promotes an enterprise to establish a competitive advantage against its competitors.

The development and diffusion of new technologies has an important role in the production growth, but according to the Oslo Manual (2004) understanding, "the process of innovation and its economic impact is still deficient."

Prahalad and Ramaswamy (2003) argue that the pressure to create value is constantly increasing, competition is intense and profit margins are getting smaller. Traditional recipes for practices to reduce costs as re-engineering and outsourcing services are no longer sufficiently, "the need to innovate is greater than ever".

According to Cassiolato et al. (2000), territorial dimension is an important element in a cluster, especially because the proximity of businesses enables the sharing of visions and economic value, as well as competitive advantages of the final product.

Clusters have their based structure on the creation of network transactions between the productive actors. The transactions do not necessarily need to be linked to a physical asset; they may include cooperative activities together such as development of research. The network organization encourages the development of relationships where the agents' behavior establishes interactions (Vilpoux and Oliveira 2010, Masquietto et al. 2011).

Environmental aspects are also important features to be considered in the innovative process. Cluster acts on a set of firms located near, within same industry, where the relationship seeks primarily in competitiveness gains. Also, the foundation of Industrial Ecology has spatial proximity of the industries as one of its characteristics.

We hypothesize that the Industrial Ecology proposals, coupled with clusters, may direct the activities of cooperation and learning among various productive sectors; they also may help as an instrument for the development of the innovative processes.

In this respect, as Cassiolato et al. (2000) discuss, policies aimed to the cluster strengthening and development are considered essential tools for the regional and economic development.

Clusters show superiority and impact on competitiveness by facilitating the dissemination of information and regionalism features. The widespread knowledge application in the cluster builds the capacity of innovation. Therefore, for the work lineation, we take on a challenge to answer: "What is the relationship of technological innovation tools with the development configuration of the industrial clusters?"

Thus, this study aims to verify some conceptual tools for the development of technological innovation, and through a theoretical and conceptual proposal, our work contributes to the structural theory of interaction of the tools in cluster, with the purpose of strengthening the production development and progress, and, to generate a strengthening of competitiveness and economic and regional development. This paper is of a theoretical and conceptual development, therefore, this work contributes with concepts related to the theoretical content, of not including practice trials.

2. Methods and Setting

Lakatos and Marconi (2001) define the method as a set of rational and systematic activities that will help achieve the goal safely, tracing the paths to be followed by checking for errors, and so, that it can assist in scientific decisions. The authors define a scientific work as a study directed to a specific theme or particular value, representative enough, and that rigorously follow the methodology.

To conduct the present study, we raised searches from the literature review of the concerning of the development of tools for technological innovation, innovation development and clusters references. The approach to the problem happens in a qualitative manner, because it believes there is a dynamic relationship between the real world and the subject that can not be translated into numbers and do not require the use of methods and statistical techniques.

For purposes of Clusters characterizing, were surveyed BNDES and IPEA. Also IPEA data is used to demonstrate the growing development of clusters in Brazil and the role of regional crop for the dissemination of information and knowledge as well as to strengthen the development.

In order to select the tools for the development of technological innovation, we used the Oslo Manual (2004) by aligning the main aspects on the national scene to the context of clusters, directing the research proposal on promoting the development of technological innovation. In order to develop the theoretical and conceptual proposal, we use Shaohonga et al. (2011) analytical study of clusters formation and evolution, to check the time of that the innovation network is formed.

Considering the moment of innovation networks formation in cluster, we adapted the management and operation model of cooperation networks proposed by Gerolamo et al. (2008), to demonstrate the application of the first two tools in the innovation circular network process. In the sequel, there is an interaction model between the companies based on the Industrial Ecology concepts, in order to create a draft methodology for the strengthening of environmentally sustainable development of the cluster innovation circular network. In order to validate these claim empirically, we present the analysis and discussion of results, and in the sequence, we present the final considerations.

From the standpoint of its objectives, this research can be considered as exploratory and descriptive, yet, as Gil (1991) noted, the exploratory research aims to provide a greater familiarity with the problem and involves literature review and analysis of examples that encourage understanding. It can also be considered descriptive by describing the characteristics of data collection and establishes relationships between variables.

3. Clusters

The clusters of firms when presented in the literature are commonly based on the importance of local issues for the development and competitiveness (Dalla Vecchia 2006).

The National Development Bank (BNDES 2000) defines the clusters as "[...] a phenomenon linked to the agglomeration economies and associated with the physical proximity of companies, strongly linked by flows of goods and services. The geographic concentration allows for mutual gains and more productive operations [...]".

The RedeSist (2003) (Network Interdisciplinary Research of the Economics Institute - Federal University of Rio de Janeiro) concept says that, where there is production of goods or services, there will always be an arrangement around which involves various activities related to its marketing.

In recent years, it is observed that innovation and knowledge are the most important elements in competitiveness. Recently, these factors are noted as local interactive processes premises.

According Malmberg and Maskell (2006), the concept of sharing knowledge - which describes the local conditions and spatial proximity between actors - enable the formation of distinctive cognitive repertoires and influence generation and selection of skills, processes and products, within a field of knowledge or activity.

The idea of productive clusters becomes associated with the competitiveness concept. This association helped in setting a new benchmark for local policy, giving focus of analysis to the productive agglomeration and as unit action of industrial policies. Regional strategies for sustainable development of different social agents have been observed as effective measure worldwide, as way of interacting and fostering the sharing of knowledge and information (Cassiolato et al. 2000).

Localized learning argument consists of two distinct elements, but related: the first has to do with localized capabilities that enhance learning, while the other concerns the possible benefits that companies with similar or related activities may accrue because they were situated in spatial proximity (Malmberg and Maskell 2006).

Based on these concepts of cluster, we observe development happens from the vertex of regional development. In this respect, the global scenario presents a current policy of areas valuation.

The notions of cluster also begin to occupy a prominent place at the national level (Vilpoux and Oliveira 2010).

The settings of the world economy in recent years - with reduced barriers to international trade, regional blocs formation, intensive use of information technology and knowledge, growth of services sector, process outsourcing and networking business cooperation - pressure companies to

implement programs and methods to improve results in several critical performance dimensions (Galdamez et al. 2009).

In this respect, we undertook an intensive research to the need to implement management tools, among others. Policies aimed at strengthening and development of cluster and productive systems are considered essential tools for the economic and regional development (Cassiolato et al. 2000).

Amato Neto (2000) highlights the importance of the dynamic aspect of cooperation between groups of companies, operating in the same supply chain, searching collective efficiencies.

The clustering of companies with similar or complementary processes enables greater benefits to its members, both to increase the power exchange between the group of companies with their suppliers and customers and also by facilitating the interaction between the agents involved in the production process. This also allows the transition of knowledge to all companies in the cluster (Hewings and Silva 2010).

The clusters development shows great importance on the Brazilian stage, as we observe by the IPEA study of the potential number of clusters identified in Brazil in 2004. Table 1 presents the number of each state.

Table 1

According to IPEA (2006), the clusters embryos exhibit attractive to the policy measures and institutional actions, which promote the creation and distribution of capabilities among local producers, with positive effects for the competitiveness and the innovation generate.

Mostly the productive clusters are made up of small businesses and it is essential the cooperation and joint actions, as this partnership seeks to compensate the inability to compete with larger companies. Therefore, such cooperation has the potential to increase production capacity, optimize costs and increase innovation capacity, which enables improvement to face the competitiveness (Petter et al. 2010).

Maturity of productive clusters is also important because of their focus on productivity. We face several examples of the practical position that can be leveraged with maturity. But productivity is not the only focus of the clusters, there is also the growing concern about the life quality of employees and partnership with research institutions. Moreover, innovation investment and social and environmental responsibility are increasing in production arrangements (Petter et al. 2010).

Several conditions must be considered for the clusters development. Cassiolato et al. (2000) pointed that the main variables and macroeconomic conditions also influence the microeconomic decisions. Therefore, it is necessary the double interaction between the micro and macro plans, for the construction of the sustainable development. According to the WTO (World Trade Organization) it is of fundamental importance the practice of industrial policies to support economic and regional development, so that this can happen in a technological and sustainable way. The cluster organization involves the development of these conditions.

As Cassiolato et al. (2000) noted, the cluster concept has some major peculiarities in its organization as: the territorial dimension, diversity, innovation and learning, tacit knowledge, and governance.

- Territorial dimension: the territory where the processes are established; region of geographical concentration and proximity that provides sharing of innovative processes, cooperative, productive and economic values and diversity. Such regional crop can provide competitive advantage as a differentiator;
- Diversity: Beyond the interaction between competitors and suppliers, there is also participation of universities, public and private sector, research and development institutions and other institutions;
- Innovation and learning: the expansion of productive and innovative capacity of enterprises are fundamentally constituted by innovation and learning through the transmission of knowledge,

integration of new processes and products, introduction of organizational formats, of which are able to bring technical changes in clusters, favoring competitiveness and generate local and collective dynamics in enterprises and institutions;

- Tacit knowledge: not measurable and not taught formally, but that can be socialized by individuals, organizations and businesses, and facilitated by direct contact and interactions provided by territorial proximity, facilitating its diffusion among companies. Besides, it becomes the key to competitive advantage by being contained in the cluster and have an access and movement hampered in external contexts;
- Governance: refers to the practices and modes of local coordination. Presents different hierarchy forms. May have participation of various actors, as the State at various levels, enterprises, workers, organizations, etc. There are several instances of coordination and local leadership that can foster the emergence of clusters, local collective forms of organization and power in decision making.

Thus, become critical the interaction of local actors, estimated in every way possible and at all levels, to the promotion of knowledge.

According to these authors, it is not possible to understand and plan development without the understanding "of the social and political fabric in which economic activities take place, that knowledge is crucial in the development process, that the state has a key role in coordinating and supporting the process"(Cassiolato et al. 2000).

The institutional and regional dimension is large part of the productive and innovative capacity, which in different contexts, are identified as fundamental in the generation and dissemination of knowledge.

Between the different strands of local clusters, tacit and explicit knowledge have an important role in the social structure. Local policies can be combined with the local routines of economic processes and the learning derived from global experiences through explicit knowledge. For this, it is also important the democratization of the involved institutions, in order to promote interactions between local actors with transparency, and to generate a policy to legitimize the current process.

4. Innovation

In the current global requirements of which involve total quality, zero defect and standardization, management practices seek to eliminate errors. So attempts to innovate, make mistakes and redo, in this environment where predictability is sought, the space for creativity and innovation become restricted (Carlomagno and Scherer 2009).

Technological innovation is a capable element of changes generating of technical- scientific, economic, sociocultural and political dimensions. Moreover, it is possible to find differences between the various experiences regarding the degree of development, integrating the production chain, articulation and interaction between agents and local institutions, and systemic capacity for innovation. Therefore, innovation in developing countries takes lots of planning (Casagrande 2004, IPEA 2006).

The development of innovation skills and its transformation into results are part of enterprise strategy. The strategy today is seen as much more than a simple plan: it is a perspective, a course of action, a "way to play the game" - and beat it. Traditional strategies are aimed at maintaining the status as the incremental growth. Strategies based on innovation are directed toward better results for the lead in launching new solutions to the market (Carlomagno and Scherer 2009).

The systemic view of innovation has stressed the importance of the transfer and dissemination of "ideas, skills, knowledge, information and signs". According to this view, channels and networks that provide the circulation of such information, is embedded in a social, political and cultural way, strongly directed or limited by the institutional structure (Oslo Manual 2004).

The systemic approach of innovation leads the policy to emphasize interaction between institutions, so that the interactive processes being conducted in the creation, dissemination and application of knowledge. Thus one can notice the undeniable role of governments to monitor and organize the overall structure (Oslo Manual, 2004).

Besides, the activity of creating products has focused solely on profit, so reports that "products are developed only to suit the aesthetic and cultural requirements and to suit the technical-economic conditions of industrial production of society"(Casagrande, 2004).

Whatever the approach to innovation, they write a comprehensive management structure that helps turn ideas into financial returns, so that when the companies launch new products or services, can apply to them these improvements, or explore new business opportunities and technologies, which strengthens competitiveness and promote social and economic development.

Due to the increasing competitiveness, production and development demand high investment. Therefore, to address this issue, it is essential to develop constantly an entrepreneurial behavior, especially because, it is noticed that the blocks to build innovations of allied companies demonstrate a greater chance of establishing a competitive advantage (Rocha 2004).

Currently, clusters are showing superior impact on competitiveness in regional economy. It is noticed that, the industries of which gain competitive advantage, have many regional characteristics, and are included in an industrial complex (Shaohonga et al. 2011).

Innovations create new markets and transform industries. These changes have important impact on customers' expectations, providing greater gains in competitiveness (Carlomagno and Scherer 2009).

According to Humphrey (2003), in clusters there is the capacity for innovation and modernization, of which is essential to get profitability ahead the global competition. The author points out that, by having this ability, which is based on not decipherable knowledge, confidence, and different institutional structures, makes it difficult for potential competitors to have access. Globalization makes local knowledge even more important.

Companies located in a cluster contribute to the development also because of their individual efforts. As a result, this increases the value for other firms in the cluster and provides additional protection as a whole. Innovation efforts by firms present in a cluster reflect to the entire cluster (Humphrey 2003). Hence, the importance of industrial and technological policies and of innovation incentives aimed at the regional level.

Industrial and technological policies long used in several countries, traditionally used as basis, a linear view of innovation, which defines the implementation of the innovative process in sequential stages, transferred from scientific institutions to the productive sector. Technology policies based on the linear view of innovation intended to tackle market knowledge backed by investment in companies, but were not spontaneously. This is considered a functional and hierarchical (top down) knowledge view, which involves science, technology and innovation. Policies based on linear view have a tendency to favor research and development focused within large companies, and the dissemination of knowledge is mostly seen only as the equipment acquisition. Agencies and institutions applying rules on incentives to innovate are also centrally managed from the top down in the linear view of innovation (Cassiolato et al. 2000).

A different innovation policy is based on interactive view of innovation, of which, according to Cassiolato et al. (2000), believes that this is a consequence of relationships between companies and institutions mainly by the contact within networks of local and regional actors, with policies to stimulate interactions among agents, so that innovation is a process of social accomplishment and collectively organized. Thus, the territorial approach has a fundamental role in order to meet the demands of local businesses, encouraging the integration of various local, being then a bottom-up policy, which provides the satisfaction of needs within the region. The interactive policies are aimed to provide stimulus to learning and diffusion of codified and tacit knowledge,

which is seen as part of the innovative process in the local companies. These policies are made up by the stimulus for new institutions and organizations, formed of a collective nature, and incentives that the businesses and other local actors to interact. The interactive policies also aim to training human resources, information, design, among others, besides technological services (Cassiolato et al. 2000). Table 2 shows the changes in innovation policies through linear and interactive innovation view.

Table 2

To Cassiolato et al. (2000) industrial and technological policies instruments directed to the industrial cluster, focused on the search for innovation, should move to a vision that emphasizes the interactive nature, leaving behind the old technology policy based on the linear view of the innovative process.

It is also important the construction of forms of coordination that motivate local knowledge systems, be they public or private coordination, making the arrangement to become a productive space that helps technological development and increase competitiveness.

5. Tools for innovation in the cluster development

This chapter studies some proposals for the development of innovation in local clusters, based on tools featured in the twenty-first century, which values the spirit of cooperation, compatible industrial attitudes to the environment and the ability to meet legal action.

5.1 Strategic alliances

An important tool for technological innovation according to Rocha (2004) are strategic alliances, as this is a component of running a enterprise that will better position themselves in the future, since, from the strategy, the enterprise may select the most important aspects of its operation, integrating major goals, policies and action sequences.

According to Carlomagno and Scherer (2009), the innovative enterprise has an organizational structure, flexible and with few hierarchical levels, “innovation comes from the organized chaos”. But the innovative culture needs to change attitudes; it has to innovate to bring results. An enterprise can have new knowledge, but if they do not apply, does not promote results.

Innovate demand several factors that make it clear that this is not an easy path, as available time and resources for immediate results hinder attempts, where it is essential to trying new solutions, and never give up (Carlomagno and Scherer 2009).

It should be noted companies that do not form strategic alliances tend to have greater difficulties to stand out, and that customers tend to become more selective, particularly into the social context that values the needs of quality, sustainability and social concern, and other behavioral changes arising from the development of markets (Rocha 2004).

The technological innovation activities require investments in research and development that does not always result in gains. The risk of not getting return on investment inhibits innovative activities, as continue doing the usual do not imply. The development of a new product or process is often long, so that short-term strategies make difficult for the enterprise to aim the future (Carlomagno and Scherer 2009).

The government has an important role in the formation and development of the innovation, whether in a single organization or in a process network of companies; it must provide an environment of industrial culture and a mechanism that can be favorable for effect the ability to cooperate and innovate (Shaohonga et al. 2011).

An strategic alliance must establish defenses to secure that each partner can contribute to the innovation process with the collaboration of research and development of solutions, for example, that could be implemented step by step, looking for ways to develop the partnership aspect of improving

the capacity of the organizations and using government incentives, such as the Innovation Law, for strengthen this process.

5.2 Law of Innovation

In Brazil, with the entry of the Law 10.973 of Technological Innovation (LIT) from December 2, 2004, enterprises count with a new tool for fostering innovation and scientific and technological research in the production environment, aimed at training and the technological autonomy and industrial development of the country (Matias-Pereira and Kruglianskas 2005).

Companies often increase the variety of products as a strategy to protect competition. Companies can create new products and expand their markets, by contrast, the consumer can make when choosing your own combination of products and services to meet their needs. However, for most consumers, the increase of the characteristics and functions of the products, and the diversity, may also create difficulty of choice. For most consumers, the variety of products does not necessarily result in better consumer experiences (Prahalad and Ramaswamy 2003).

Search through the competitive range of products offered stems from the premise that companies create value through product and service, in turn, leads to an innovation-centric view. With the increase in consumers becoming more informed and a continuously changing of competitive landscape, there are challenges to this vision. It is significantly easier to create a variety of products. But to compete effectively only by the variety of products are no longer (Prahalad and Ramaswamy 2003).

One way to expand the development of innovations, there are the incubators, which facilitate access to infrastructure and human resources with new companies. The Brazilian Law of Technological Innovation seeks to regularize the situation of private companies within the universities and recognizes the importance of transforming S&T and R&D in new products and processes or improves existing ones, in order that final products meet the expectations of domestic and international markets (Matias-Pereira and Kruglianskas 2005).

According to research conducted by Matias Pereira and Kruglianskas (2005), there is some doubt the consistency of the Law of Technological Innovation, which should function primarily as an instrument of support for the vicious circle of technological dependence in Brazil is broken.

It is noteworthy that the Law of Innovation, when it attempts to establish a dialogue between the institutions that produce knowledge goods and the production of goods and services, emerges more as a tool to facilitate the creation of a culture of innovation in the country, however, alone is not sufficient to change the existing situation in the field. Although the tools are available, there must be a greater involvement by stakeholders (Matias-Kruglianskas and Pereira 2005).

The three main axes of the Law of Innovation are organized around: the creation of environment that fosters the partnership between universities, technological institutes and businesses; stimulating the participation of institutions of science and technology in the innovation process, and; encouraging innovation in enterprises (Law nº 10.973; Matias-Kruglianskas and Pereira 2005). It is noteworthy that on December 15, 2010 comes into force Law nº. 12.349, which go into effect some changes in the Law 10.973, of December 2, 2004.

Law of Innovation is a tool to help enterprises not only to offer variety of products, but, to offer products of a technological base, creating a unique value for customers and straightness national enterprises.

5.3 Industrial Ecology

According to Casagrande (2004), the development strategy and a process of technological innovation must consider the socio-environmental issue, and, the development of technologic parks

or industrial cluster need to align the guidelines of sustainable cities, which is part of the Brazilian Agenda 21.

The Brazilian Agenda 21 is an instrument of participatory planning for sustainable development of the country. According to Agenda 21, many of the problems and solutions have their roots in local activities, so the participation and cooperation of local authorities are determining factors for the achievement of its objectives (Ministry of the Environment 2011).

The Industrial Ecology proposals together with the concept of clusters to consider the environmental impact, may direct the activities of cooperation and learning among various productive sectors, focused on sustainable innovation.

A central element of industrial ecology is the concept of closed loop systems, where energy and waste are continuously recycled between geographically close companies. This process is defined as industrial symbiosis. The engineering strategies are essentially tubes to tubes in order to integrate innovative engineering solutions as the basis for a sustainable industrial system (Hewes and Lyons 2008).

In an Industrial Cluster (commonly concentrated companies of the same sector) may occur the lack of resources, for example, if an enterprise depends on the waste of another. For that, it is proposed the integration of the cluster to be combined with companies of other segment, from the approaches of Industrial Ecology and the concept of Industrial Symbiosis, which according to Deutz and Gibbs (2010) Industrial symbiosis transactions by their very nature involving byproduct material and energy exchange.

Three approaches are presented by the Industrial Ecology, distinguished by their scale of operation. They may be within the enterprise, between companies, or on a regional scale, and one of the strategies in those approaches is the concept of Industrial Symbiosis (Pereira et al. 2007). According to the authors, in an industrial symbiosis is viewed as the cooperation, both in production processes within an enterprise and between several different companies, which trade and share various services and materials. The concept is based on the synergy between different productive activities with higher resource efficiency, coupled with environmental and economic benefits (Pereira et al. 2007).

The three basic pillars of industrial symbiosis, according to the authors, are the geographic information, organizational information, and information processes. These are the basis for the connection between local companies and exchange of byproducts, especially for companies located in the same region or industrial park (Pereira et al. 2007).

These pillars of industrial symbiosis promote the interconnectivity of industrial activities facilitating the planning of local industrial systems with efficiency and more closed material cycles. Without the presence of one of the pillars, the theoretical conception of the industrial symbiosis process becomes invalid (Pereira et al. 2007).

But if the network acts on its three bases, it may seek a relationship with another larger network instead of acting only in a local structure. Several companies can create opportunities to share services and facilities while improving their environmental, social and economic performance in the region. The proposal goes beyond the exchange of byproduct; it aims at the whole scenario, involving a network of interconnectivity between industries, and acting at companies, organizations that manage industrial parks, and companies owned by other parks. The process of interconnectivity becomes a marketing relationship between the companies involved, and may include the recovery of materials, to the joint training programs and community care services (Pereira et al. 2007).

According to Pereira et al. (2007), the expansion of the network becomes to act on two bases: the marketing and logistics. The first is based on the direct relationship between supply and demand, while the second is based on means and methods that facilitate the flow of materials and goods.

According Heeres et al. (2004), there may be some barriers in the establishment of exchange symbiotic relationships: an enterprise may run into five different types of barriers: Technical (the exchange is technically unfeasible) Economic (an exchange might be economically unsound or economically risky from an enterprise perspective) Informational (the right people do not have the needed information at the right time), Organizational (the intended exchange might not fit in the current corporate organizational structure), Legal (caused by the jungle of environmental laws and regulations).

The learning brought from the development of productive arrangements can assist in difficulties with the projects implementation policies for industrial ecology, in addition, to providing a rigorous theoretical framework. On the other hand, knowledge of industrial ecology provide guidelines for regional development policy about how the environmental impact of economic development may be mitigated, fundamental point in the context of current environmental concerns (Deutz and Gibbs 2010) and strengthen the sense of cooperation.

Through the concept of local production clusters, integrating it with the approaches of Industrial Ecology and the concept of Industrial Symbiosis, we argue that the possibility of overcoming the barriers tend to be strengthened, once clusters are coupled with proposals of Industrial Ecology.

6. Theoretical and conceptual propose

Our theoretical analysis is divided into two axis of application. At the first one, the axis of application involves the stages of the cluster development, to verify the applicability of two of the tools. In this axis, there is a formation of a cooperation network and maturity of the cluster to an innovation network, where strategic alliances tend to spread and the Law of Innovation tends to work on a consolidated basis.

In the second axis, once the strategic alliances and functionality of the Innovation Law are strengthened, we suggested a proposal to apply concepts of Industrial Ecology, in order to strengthen the environmentally sustainable development of the cluster, since, according to Shaohonga et al. (2011) the circular cluster innovation network is already a model of environmentally sustainable development. Concluding, it is made the analysis and discussion of results.

6.1 Application Axis 1 – circular cluster innovation network

According to the analytical study of the formation and evolution of regional industrial clusters based on the self-organization theory of complexity systems and synergistic method, performed by Shaohonga et al. (2011), “the forming and the evolution of regional industrial clusters generally go through several phases as follow: enterprise groups, Industrial clusters and circular innovative networks”.

Initially, some cores of industrial agglomeration appear in a given region, attracting and directing the business of that locality. “Through enterprise’s horizontal and vertical self-production, and self-organized division of labor based on specialization, enterprise community is gradually formed” (Shaohonga et al. 2011).

Then, “under the non-linear reaction on each other, all the subsystems come to coordinate with others”, which will provide an increased maturity, increased efficacy and self-organization, becoming in fact an industrial cluster (Shaohonga et al. 2011).

In the third phase, the production arrangements can be directed to a circular network of innovation, being a self organized process that is the result of the cluster development in a more advanced stage. The circular network of regional innovation is an environmentally sustainable development model, where there are more creative and competitive vitality and advantages. In the

process of implementation, it is of fundamental importance the domestic law of production clusters evolution, besides the importance of creating a favorable ecological conditions in the region, adjusting to the external environment, and, leaving mechanism of self-organization in the cluster to play its role, since the environment in which organizations operate is structured by means of productive and technological linkages between the various relationships networks (Masquietto et al. 2011; Shaohonga et al. 2011).

Therefore, in the third stage, we see as the better moment for the application of tools: strategic alliance and the Brazilian law of technological innovation, where, strategic alliances have a purpose to develop the partnership to improve the learning capacity of companies to effect that advances occur, while the innovation law that has the objective and the role of "promote and encourage scientific development, research and technological expertise" in order to strengthen the development (Rocha 2004; Matias-Pereira and Kruglianskas 2005).

Through regulations on collective action and cooperative compensation to balance the interest of several companies, mutual interest and benefit can be achieved through cooperation. "Only those innovation networks created on mutual benefit and interest, they can have lasting vitality" (Shaohonga et al. 2011), with the prospect of new innovations and interactions, enabling the application of some concepts of Industrial Ecology.

From the application of technological tools and operational with the implementation of methods and cooperative actions, the performance of the innovation process tends to strengthen in the industrial cluster (Gerolamo et al. 2008). Cooperation followed by evaluation process performance promotes the process of continuous innovation.

6.2 Application Axis 2 – strengthening of environmentally sustainable development

According Deutz and Gibbs (2010), by the nature of a regional industrial cluster with inter-relationships and the expectation of a competitive advantage for the participants and the benefits of economic development for the host community, the policy of Industrial Ecology can be conceived as a sort of cluster policy. Clusters based on Industrial Ecology can be seen as a distinct form of clusters in the tradition of regional development.

Therefore, the success of the application of industrial ecology propose will depend on a scientific research program aimed at the total use and reuse of all factors of the system, embedded in an implemented environmental management program, acting both at an enterprise, as between different industries (Giannetti et al., 2003).

According to Giannetti et al. (2003), the sketch of a set of industrial units interconnected; work to form larger units, such as industrial parks and clusters. For the author, "the complexity of the set can increase at various levels, for example: the number and diversity of industrial units and number of interactions within the set. An enterprise can buy waste from more than one vendor, or may sell their waste and/or byproducts to more than one enterprise" (Giannetti et al. 2003). Accordingly, by applying this scheme in a cluster, the chain will be expanded.

The remarkable economic importance of Industrial Cluster for regional development and competitiveness, are perceived as common features of the development strategy of Eco-Industrial Parks.

7. Analysis and discussion

When the innovation process takes place continuously, it provides that the enterprise can establish a competitive advantage against its competitors. Strategic alliances between firms are important for that the construction of the technological innovation process happen in a simple and effective way (Rocha 2004).

For Matias-Pereira and Kruglianskas (2005), the Law of Technological Innovation was held from the focused discussion on resources achieving institutional aspects of which now must be implemented. The authors consider it important to preserve the identity of actors such as universities, industries and companies, in order that the law being an important instrument for promoting industrial and technological policies in Brazil.

As the industrial system is considered responsible both for the generation of products, such as waste, the boundaries of an industry extends to the environment by requiring responsibility of the products and waste by industry and across industries (Giannetti et al. 2003). According to the authors, the most critical aspect of this new concept of responsibility to the environment arises from the effective cooperation between companies.

Therefore the importance of combining strategies of Industrial Metabolism and of Industrial Ecology, both by environmental and economic concern (Casagrande 2004; Giannetti et al. 2003), with the purpose of effecting cooperation between enterprises, because the reduction of materials and energy saves money, and minimizing or eliminating waste reflect economy in collection, processing and transportation. Moreover, it is clear the importance of all the interaction support that the innovation law represents, mainly, encouraging strategic alliances between the various actors involved in the productive process and of innovation generating, strengthening the cooperation between them.

The adding value that a sustainable product represents can also be a strategy for business competitiveness (Casagrande 2004), besides being an alternative to innovation generating.

To implement the Law of Innovation it is important that there is an effective interaction of government actions with the private sector and the scientific and technological workers. It is noticed that the Law of Innovation is an important institutional instrument in support of industrial and technology policies at the national level (Matias-Pereira and Kruglianskas 2005).

The Law of Technology Innovation provides regulation while strategic alliance promotes the strengthening of cooperation. These tools, when applied in clusters, provide increased capacity to innovate and leading economic, social, and environmental and competitiveness gains.

In this sense, the results obtained through the axis of application of theoretical and conceptual proposal, we answer the following research question: "What is the relationship of technological innovation tools with the development configuration of the industrial clusters?"

In the application axis 1, the support provided by the interaction of innovation law favors the formation of strategic alliances and regulates the participation of other actors in the process, as, researchers, social groups, individuals, economic agents and government agencies, so that the scientific potential, economic and social needs being succeed. The strategic objectives are favored by the network of cooperation, and, the evaluation performance measurement drives the development process. This interaction promotes the increase of the capacity to generate innovation, enabling increased competitive advantage for clusters.

In the application axis 2, since the circular innovation network is strengthened, we notice that the proposal to apply concepts of Industrial Ecology tends to strengthen the environmentally sustainable development of the cluster and to strengthen the working set of industrial units interconnected to form larger units, in number, diversity, and quantity of interactions within the group, expanding the chain.

Therefore, this study shows that the raised tools to generate innovation are related with the development configuration of the industrial clusters, contributing to the development of the cluster and to the innovation process.

8. Conclusions

The territorial dimension is an important element for a Productive Arrangement and regional location is a cut for the implementation of development policies. The proximity of the enterprises enables the sharing of economic values and vision, as well as competitive advantages of the final product.

Information and knowledge make up key resources for the economic and productive development in knowledge management. The conceptual bases of local production clusters presented in this paper show that the fundamental aspects of knowledge management are there applied. These references serve to note that good knowledge management built into the clusters governance may promote the progress of the clusters when well set in the new paradox.

It is important to the construction of coordination forms that motivate local knowledge systems, causing the cluster to become a space that helps in technological innovation and increasing competitiveness, since the development of local productive clusters are identified as important feature of development on the national scene.

Innovation has a comprehensive management structure that helps to turn ideas into financial returns, for that enterprises may implement improvements in its processes, products or services.

To this end, we note the importance of the various actors' interaction, such as researchers, social groups and individuals, enterprises between enterprises, economic agents and government agencies; so that the scientific potential, economic and social needs getting succeed. Cooperation and a process of evaluation performance are important for furthering the continuous innovation process and are important to be thorough in continuing studies.

The assumptions of Industrial Ecology involves the participation of two or more enterprises interacting their activities in order to reduce the impact on the environment, thereby causing less impact than that of each enterprise acting independently. The interactions between companies, in addition to environmental benefits, tend to result in economic and social gains and tend to promote the innovation of processes and products.

The approaches presented by the Industrial Ecology, distinguished by their scale of operation, may be within the enterprise, between enterprises, or on a regional scale. For this it is important to know the local characteristics, capabilities and limitations, to guide the development through the attraction of economic activities, compatible with the ecological vocation and the actual capacity for sustainability.

In an industrial ecosystem operate a network of companies and organizations with joint action and seeking to improve their environmental and economic performance. Industrial cluster, (that usually involving several companies of the same industry) by combining the proposed of Industrial Ecology, the focus and learning can occur between various productive sectors. Strategic alliances between companies are identified as a feature tool for the technological innovation process, and, the innovation law plays an important role to enable the research and scientific development.

By integrating proposals for a cluster with ways to search for cleaner and sustainable production and consumption, the proposition of Industrial Ecology gains strength within engineering, as an integrating strategy of industrial processes and their integration into the ecosystem.

It is observed of the literature review, as a result, that the practices of knowledge management, allied into industrial and technological policies, directed to local clusters, within a political vision of interactive nature, are significant for the innovation process and to the economic and regional development. By applying the tools of technology innovation and operational them with the implementation of methods and cooperative actions, the performance of the innovation process of the industrial cluster tends to strengthen, so then the cooperation followed by performance evaluation process promotes the continuous innovation process.

These results may contribute to the field of engineering study, to develop new ways assuming local development toward global, within logic of the knowledge sharing. The relationship of the concepts of tools for the innovation development and clusters reported here, demonstrates that the integration between them, in a structured and well managed way, can impact on aspects of the new social paradox based on the knowledge and cooperation.

To continue this research, its application is interesting in Brazilian Clusters mapped by IPEA, in order to apply the tools defined in the axis 1, followed by a performance evaluation process, so then to apply the instrument defined in the axis 2, comparing the results obtained with the effective generation of innovation.

Through the theoretical and conceptual proposal, we find that there is a relationship between the tools presented in the survey, with the clusters, and that the productive arrangement makes it easier to disseminate these tools of its ease context of transactions between productive actors. By extending the capabilities of technological innovation in an industrial cluster, we also extend the possibilities of regional development, competitiveness, economic, social and environmental gains.

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Tables

Table 1 –Number of potential clusters identified in Brazil

States	Total of settlements	Center for Development Sector- Regional	Vector of Local Development	Advanced Vector	Embryo
SP	72	18	15	16	23
MG	80	17	15	25	23
RS	63	11	7	35	10
SC	53	12	2	30	9
PR	61	9	8	30	14

RJ	34	5	3	21	5
CE	19	7	3	4	5
BA	53	9	14	14	16
PE	36	3	3	24	6
GO	30	3	2	17	8
ES	25	5	1	17	2
PA	15	2	1	9	3
MA	15	1	1	11	2
PI	9	0	0	5	4
TO	10	0	0	9	1
AL	11	3	0	7	1
SE	16	3	0	7	6
AM	20	0	0	20	0
RO	21	0	1	16	4
AC	5	0	0	4	1
AP	4	0	0	4	0
RR	0	0	0	0	0
MT	39	1	5	13	20
MS	29	3	0	17	9
RN	22	3	0	11	8
PB	20	2	4	12	2

Notes. Prepared based on data from the Annual List of Social Information 2000. Source: IPEA-Consolidated Report (2006)

Table 2 - Changes in Innovation Policy

	<i>Linear Policies</i>	<i>Iterative Policies</i>
Dominant strategy	Policy of technology offer	Policies focused on interaction
Goals	Hierarchical Diffusion of Knowledge Encourage R&D in Large companies Disseminate the knowledge embodied in equipment	Bottom-up approach Fostering learning in companies and organizations Spread knowledge through the network of local businesses Meet the needs of enterprises
Instruments	Timely public funding Grants and incentives (particularly tax)	Funding for networks Formation of new institutions aimed at the collective learning Provision of technological services collectively
Organization and Management	Centralised Management Administration of public resources Companies Financing	Management through intermediary organizations

Notes. Source: Cassiolato et al. 2000