

# TECHNOLOGICAL AND KNOWLEDGE DIFFUSION THROUGH INNOVATION NETWORKS

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This paper is a study about innovation and its role in transforming society. Currently, organizations need to be more competitive to keep itself in a dynamic and globalized market. Innovation emerges as a strategy for survival, as well as a competitive advantage for organization. Innovation and knowledge management creates new business opportunities and acquisition of assets. Organizations meet to development of an innovation, forming networks of innovation in order to reduce the innovative process' risks and improve their technology knowledge.

## 1. Introduction

Currently, the life cycle of products decreases, while the need of organizations to improve their products and services increases. R&D activities costs grow in an attempt to supply needs inherent dynamism of the capitalist market. The organizations endeavor to remain in the market and monitor their competitors - competitors are willing innovating their products, services or management processes to gain market - in order to overcome them.

Many organizations value the stability, protecting old ideas and techniques in place of renewal and creation of new ideas. Consequently, they do not become sufficiently competitive to survive or to remain in a satisfactory position in the market. According to Porter (1990), organizations that have the ability to deal with pressures and challenges get greater progress in relation to theirs competitors and become more competitive and profitable. Another advantage is the capacity to understand and predict changes in the market, in order that identify and feed beforehand new opportunities for innovation.

The organization uses their knowledge and gets a product, service or process throughout process of innovation. Usually after a certain time, the result of the previous process of innovation suffers a process of incremental innovation. Result of this new process is adapted to meet new needs of the market. Thus, the organizational knowledge generates new knowledge to be reused and recombined in the process of incremental innovation, which may suffer the same process. It illustrates cyclical nature of knowledge in the innovation process.

The organizational knowledge is a determining factor for development of innovation. When an organization decides to innovate, it takes risks. There are risks normally derived from the changes. Innovation requires an appropriate management of process. Therefore, the ability of evaluation and selection of projects is an important dimension of the activities of R&D. Knowledge management allied R&D activities can optimize the process, increasing the innovative capacity of organization.

Innovation comes through extremely complex processes. These processes are related to the emergence, dissemination and combination of knowledge, beyond the transformation of knowledge into new products, services or processes. During the transformation of knowledge, the activities are not necessarily linear, have feedback mechanisms and relations of cooperation between various bodies such as government, university and industry, as observed in the Triple Helix model and between different areas of knowledge such as industry, science and technology, politics and economy.

This paper is a study on role of knowledge management and technological innovation, both combined under forms of cooperation for organizational potential improvement. In section 2, there is a review of the literature about innovation. In section 3, it highlighted the importance of knowledge management for innovation. In section 4, innovation and technological diffusion are discussed. In section 5, there is analysis about networks of innovation. In section 6, innovation analysis models are studied. Section 7 concludes paper and presents suggestions for future works related to this topic of research.

## **2. Revision about Innovation**

According to Marx (1890), innovation is way to get temporary monopoly on superior technique or differentiated product. One of the principles of evolutionary theory is dynamic economy, following Marx and Schumpeter. Dynamic economy is based on innovations in products, processes and forms of organizing production (Tigre, 2006). In doing so, innovations are not necessarily gradual. They may take a radical character that results in instability in the economic system, alternating periods of crisis and prosperity.

Schumpeter made an important distinction between invention and innovation. Invention relates to an idea, sketch or model for improvement or creation of product, while innovation occurs with the effective implementation of invention (Freeman and Soete, 1997). Consequently, it is possible to realize the coexistence of the invention and innovation.

According to Oslo Manual (Finep, 2004), developed by Organization for Economic Cooperation and Development (OECD), all innovation must contain some degree of novelty. Four types of innovations are defined: product innovation, process innovation, organizational innovation and marketing innovation. These innovation types contain a wide range of changes in the company activities.

Product innovation is technological upgrading of existing product or developing a new product technology. Developed product must have different characteristics from

other products previously developed by the organization. Products which have only aesthetic changes or which are only sold by the organization and developed by another one are not considered innovations.

Innovation process is the usage of new or improved production technology, as well as methods for handling and delivery new or improved products. Results obtained with this type of innovation change quality and production and product delivery costs.

Organizational innovation is a change in the organization management structure. It can occur in the form of links between its different areas, expertise of employees, relationships with customers and suppliers and business processes.

Innovation marketing implements new methods of marketing, including changes in design of product or package, promotion or placement of product and methods of establishing prices for goods and services.

Initially, innovation is result of interaction between scientific discovery, spreading economic and political power. Innovation systems are designed to develop more than simple changes - transformations that challenge analytical understanding, in the same way that change *status quo*. Concepts are being reshaped. This way, interest on past good performance is replaced by interest in importance knowledge gained has for the future. Nowadays, the problem is how to recombine existing knowledge in improved and new ways in order to supply future demands (Etzkowitz, 2002).

### **3. Knowledge Role in Innovation Process**

According to Penrose (1959), firm is a collection of resources. Creation of new productive services depends on capacity to internalize knowledge needed to develop them and produce them efficiently. The services, generated from new knowledge, depend on training of workers involved in its use. Development of this training is defined in part by resources available for the workers.

Consequently, survival and success of an organization are linked not only with external factors, but also how the organization uses and incorporates knowledge. This method depends on individual and collective capacity of organization. According to Nonaka (1996), knowledge is contextualized in tacit and explicit. Tacit knowledge is personal, difficult to communicate and formalize and belongs to a context specific. While explicit knowledge is transmitted in a formal and systematic language. They are not entirely separate, but complementary, since no experience is not possible to obtain a real understanding of something.

Many innovations are improvements of products, services or processes - incremental innovations. These innovations are based on past experiences and knowledge, i.e. explicit and tacit knowledge. This knowledge generates personal knowledge, which its turn results in organizational knowledge. Experiences and organizational knowledge used in productive activities are important inputs to innovation process.

Efficient dissemination of information and communications technologies permits an increasing transfer of explicit knowledge. However, the transfer of tacit knowledge

remains extremely difficult (Lastres, 2004). It impedes development of innovation due to its importance in this process. In an effort to overcome these difficulties, it is necessary to understand systems and local productive arrangements in order to investigate relationships between organizations sets and other participants with their flow of knowledge.

Knowledge in organizations is a competitive advantage and a decisive factor for innovation. Dissemination and sharing of knowledge in the organization, through Knowledge Management should be widely encouraged. Social and cultural barriers imposed and that ultimately hinder acquisition of knowledge must be overcome in order to allow for transformation of personal knowledge into organizational knowledge.

Knowledge, in all its forms, plays a crucial role in current economic processes. Nations have a performance better than other when develop and effectively manage their assets of knowledge (OECD, 1996). And, innovation seems to play a central role in a economy based knowledge.

#### **4. Innovation and Technological Diffusion**

According to Edquist and Johnson (1997), technological innovation is introduction of new knowledge or a new combination of existing knowledge in the economy. That is, innovation is result of a process of interactive learning. It is possible to obtain new knowledge or a new combination from different parts of knowledge through interactions in the economy.

Adam Smith (1999) was the first to recognize relationship between technological change and economic growth. He identified two innovations that promote growth of productivity, when following structural changes occurred in England in the eighteenth century: division of labor and development of machinery.

In reference to Tiger (2006), the major technological changes are accompanied by economic, social and institutional changes, since technology doesn't spread in vacuum. In other words, innovation requires legal systems, economic motivation and political and institutional conditions appropriate to develop.

Technological change results of innovative activities, such as R&D investments, besides create opportunities for greater investments in productive capacity (Finep, 2004). Generation of new jobs and additional income are long-term results through technological changes.

According Maculan (2002), technological change follows a trajectory and its result is innovation. This trajectory is constructed based on dominant paradigm and contemporary change. Innovation is a selective activity and has an exact purpose. The technological trajectory is a mechanism that selects the technological alternatives available to achieve this purpose.

Freeman and Soete (1997) classify innovation according to their impact on technology, i.e. which intensity of technological change caused by innovation. This classification consists of four types of technological change: incremental, radical, new technological system and new paradigm technological and economic, as shown in table 1.

Users and consumers' needs (demand-pull), opportunities offered by advances in science and technology (technology push) and costs of production factors induce innovation (Tigre, 2006). According Tidd (2006), adoption of an innovation will depend on interaction between two factors: demand and supply. By contrast in less developed countries, main induction factors are consumers' demands and costs of production factors.

Table 1. Taxonomy of technological change (Freeman and Soete, 1997).

Change Type	Characteristics
Incremental	Continuous improvements and modifications. Its source is not necessarily from R&D activities. Usually, it is result of accumulated learning and internal training.
Radical	Discontinuous changes in technology products and services. It creates a new technological route. Usually, it is a R&D result.
New Technological System	Changes that affect more than one sector and giving rise to new economic activities.
New techno-economic paradigm	Changes that affect the entire economy.

Organization can develop and implement a technological innovation or acquire it from the other organization through process of technological diffusion. In doing so, innovations broadcast and reach different consumers, countries, regions or markets through diffusion (Finep, 2004). Diffusion process is extremely important, because without it there is not how an innovation generates an economic impact on society.

According to Rogers (2003), diffusion of innovation is a process in which an innovation is spread through certain channels over time among members of a social system. It is possible identify four main elements in this definition: innovation, communication channels, time and social system. Innovation itself is defined as an idea, practice or object used by other individuals or segments. Communication channels are means by which information is disseminated. Time is development of innovation, adoption of an innovation by individual or group and rate of adoption. And finally, social system is group of individuals with a common goal - adoption of innovation.

Following innovation characteristics influence the rate and extent of its spread: (i) relative advantage towards rival, compatibility with target consumers' values, experiences and needs, complexity to be understood and used, test capability with pre-defined parameters and level of visibility of innovation (Rogers, 2003 and Tidd, 2006).

Technological diffusion process can be analyzed from four dimensions (Tigre, 2006). Firstly, direction or technology strategy involves decisions in various aspects for creation of a new technology and its adaptation to demand. Besides, it affects the future of innovation.

Second is rate of diffusion. It is speed which society adopts innovation adopted. It can be represented by a logistic function of growth known as "Law of Pearl". Increase companies adopt a new technology depends increase companies already assimilate technology and have potential to assimilate in model analyzed by function.

Third dimension is conditional factors. They act not only positively in order to stimulate adoption of innovation, but also negatively so as discourage adoption. Factors' nature may be: (i) technical, usability determines it; (ii) economic, cost of acquisition and deployment of new technology, such as risks and expectations for return on investment, determine it and (iii) institutional, available incentive tax for innovation, favorable investment climate, trade and investment international agreements, intellectual property system, existence of human capital investment and support institutions, social stratification, culture and religion and political system determine it.

Economic, social and environmental impacts compose fourth dimension. Technological innovation diffusion sources these impacts. Diffusion can generate economic impacts, affect industrial structure, destroy or create markets, sectors and companies, change economic growth pace and competitiveness between companies and countries. Diffusion of innovation generates social impact, such as change volume of jobs and source or elimination skills, and environmental impacts.

Generally innovation activities need to interact with several innovation system components. Among these components are government laboratories, universities, policy departments, regulators, competitors, suppliers and consumers. Innovation process interactions are internal and external.

Internal interactions play an important role for innovation. Internal information supply of innovation process can be improved through mapping relevant organizational knowledge to innovation and identifying which organization parts are important source of information for innovation activities.

External interactions were classified into three types: open sources of information, cooperative innovation knowledge and technology acquisition (Finep, 2004). Cooperative innovation occurs as active cooperation with other companies or research institutions. It results creation of innovation networks, which will be addressed further in the next section.

## **5. Innovation Networks**

According to Porter (1990), organization can be part of a cluster of large national customers, suppliers and industries have a major competitive advantage, because it has a better vision about future needs of market and technology. Another way to organization obtain a competitive advantage is identify its major rivals in the market, use this information to compare its performance and use results of this comparison as a stimulus for growth and innovation.

In agreement Piori e Sabel (1984), Ford's crisis and fall in global demand resulted in new cooperative arrangements based on flexible specialization. These new forms of production seek to reduce costs, stimulating innovation and greater flexibility in volume and diversity of production.

It is interesting to note that development of new cooperative arrangements occurred mainly in industrial districts and groups with cultural, social and institutional ties favored

cooperation and trust. These links are important factors for cooperative arrangements development. Thus, members of the network condemned opportunistic behavior.

According to Tigre (2006), firm networks emerge in organizations because they abandon peripheral activities and transfer them to other organizations. These activities are essential to profitability and safety organizational. Relationship between participants of networks is guided by long-term agreements, mutual commitment with investments in specific assets, logistics integration and unified quality management.

Virtual networks expand organizational reach. They transpose economic limits of industrial district going beyond geographical boundaries. As time goes by, new users join network, its size increases and possibilities of communication between members appear with creation of new connections. So network grows, it becomes more useful to its members and more attractive to new members.

According Lastres (2004), local production and innovative systems (SPILs - Sistemas Produtivos e Inovativos Locais) are sets of economic, political and social agents. Each set is located in same territory and developing economic activities related. These activities are production, interaction, cooperation and learning activities. SPILs keep organizations that work in the area of education and training, information, R&D, engineering, promotion and funding. SPIL is a network of innovation, because of its potential in the area of R&D and cooperation.

Collaboration networks between organizations and public institutions of R&D are widely recognized as an important form of organizational innovation. Innovation *locus* is present in inter-organizational relationship networks so they can support the scientific and technical knowledge flow and improvements (Nesta and Mangematin, 2004).

Interaction and collaboration are important external technological expertise sources. They result in an increase in productivity and competitiveness of organizations through innovation (Freeman, 1991). Thus, a network improves innovation and provides a differential to organization.

Innovation networks structure is related to holding policy industry development about a specific set of knowledge and technologies. According to Freeman (1991), there are 10 subdivisions to innovation networks, as shown in table 2. These subdivisions are not exclusive, that is, organizations may be part of different categories simultaneously.

Organizations can expand to international market. For this, they use their national advantages in other nations through alliances or coalitions. These alliances can take different forms among the innovation networks subdivisions.

According to Tidd (2006), purpose for creation of a network may be development of new product or process through combination of different skills that each participant has or meeting of stakeholders interested in adopting and combining innovative ideas.

Participants join due to having interest in same geographical area (cluster) or to being part of a supply chain that tries to develop new ideas for improving system. Participants know that networks provide stimulus necessary to obtain solutions through innovation.

Table 2. Categories of innovation systems.

Subdivisions of Innovation Networks
Joint ventures and research corporations.
Cooperation in research agreements.
Technology transference agreements.
Direct investment driven by technological factors.
Licensing and agreements of outsourcing.
Sub-contracting, production sharing and supplier networks.
Research associations
Research programs sponsored by Government.
Databases and networks of aggregated value used exchange information technical and scientific.
Other networks, including informal networks.

According Oslo Manual (Finep, 2004), cooperative innovation is a type of external interaction or knowledge flow and technologies businesses. It is defined as an "active cooperation with other companies or research institutions for innovation activities (which may include purchases of knowledge and technology)."

There is active involvement of several organizations in the design of innovation in cooperative innovation. Thus, organization has access to information and technologies that could not achieve in isolation. Besides, cooperation has potential for synergies, which participants learn from each other.

Network is heterogeneous. As a result of its various participants often play distinct roles. It is possible to establish relations between participating organizations through four elements: objective of network, dependency between participants to reach goal, implementation of connections between participants and sharing of costs, profits and risks (Lastres, 2004).

It is important for adoption an innovation that it is inedited to all nodes of network and market. Consequently, motivation and encouragement during R&D phases will be equal and all participants will be interested in development, acquisition and use of innovative results.

Organization provides a hierarchical coordination of its process through direct control of main steps of production chain. This way, transaction costs of relations between independent enterprises are minimized. Currently, institutional and technological changes and relations with market have been demanding greater production specialization and more structured forms of cooperation between enterprises (Tigre, 2006). Gradually, networks of firms have replaced verticalization model, in order to address these needs. Companies specialize in their core competencies in networks of firms, while maintaining its scope in the market that it operates.

Several factors stimulate formation of networks: fusion technology, globalization of markets, information and communication technologies and flexible specialization (Tigre, 2006). Fusion technology occurs when technology becomes so complex that no company can develop necessary skills to act at all stages of production chain.

Market globalization happens through open trade and growing competition. It encourages alliances between companies, seeking to obtain forms of empowerment, to

resolve problems of more competitive environment. Information and communication technology facilitate cooperation and communication between different organizations and allow information exchange and knowledge management. Flexible specialization is a characteristic of networks to respond market and technology changes. In doing so, network participating adapt to change better than isolation.

Participating organization of a network should define its goals and assess its role and mobility in production chain. That's why it can identify profitable cores and prevent competitive cores. Profitable cores are composed many nodes that aggregate value to organization while competitive cores are composed many nodes which price competition is more stimulated.

Organizations don't choose its network position freely. Unfortunately there are inequalities between network participants. Therefore, organizations need to evaluate network before join it, to create appropriate strategies and to identify profitable core for their participation results in qualitative and quantitative benefits.

## 6. Innovation Analysis Model

### 6.1. Innovation Zones

Tidd (2006) mapped different types of innovation networks to identify their specific needs and improve network management. Diagram has four zones. Areas are positioned on coordinate axis according to similarity of participating organizations. Areas of abscissa axis are positioned according to radicalism that innovation has developed in comparison to current innovative activities known, as shown in Figure 1.

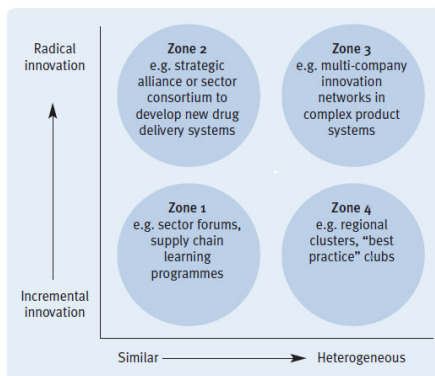


Fig. 1. Types of innovation networks.

Area 1 has companies with a similar orientation. They work with issues of tactical innovation. Usually they are clusters linked adoption and modeling of "best practice" in production. In this type of area, issues to be addressed involve training of networks for sharing experiences, disclose information, build trust and transparency and implement a system that shares goal related to innovation.

Area 2 involves participants with similar orientation, besides industry that creates and explores new concepts of products and services, such as biotechnology and pharmaceuticals networks. In this case, main interest is to explore and challenge existing limits. Information and risks are shared, usually as joint ventures and strategic alliances.

In zones 3 and 4, participants are very heterogeneous and bring different parts of knowledge to network. In order to mitigate risks of knowledge revelation, it is necessary to ensure a careful management of IP and establishment of basic security rules. Source of this type of innovation involves many risks, which makes critical investments in risky environments and encouraging cooperation.

**6.2. Innovation Radar**

Sawhney, Wolcott e Arroniz (2006) proposed a framework called Innovation Radar, shown in Figure 2. This model shows all dimensions in which an organization may search opportunities for innovation. Innovation Radar is divided into four main dimensions: offers created by company, customers attended, processes employed and opportunities used to take their offerings to market.

Besides these four main areas, there are eight dimensions of business system. These subdivisions orient organization. Thus Radar Innovation contains 12 dimensions in total, which are in figure 2.

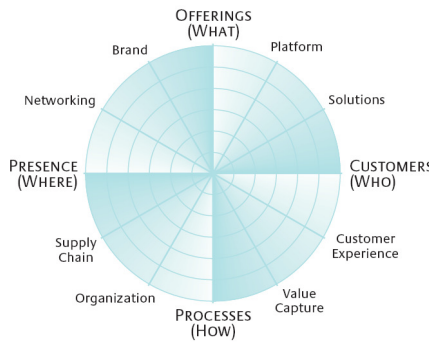


Fig. 2. Innovation Radar and its 12 dimensions.

**6.3. Potter’s National Diamond**

According to Potter (1990), innovation creates pressures and challenges. It also arises when certain challenges are identified by organization. Organization leader plays an important role in creating an environment conducive to innovation. One of its key tasks is to create conditions necessary for innovation. National Diamond or Diamond in Potter helps organizational decision make towards this goal. It describes competition in the industry and becomes a useful tool.

Diamond of Potter is a proposed model to help understand competitive advantage of nations. It has 4 factors that are linked between companies: strategy, structure and rivalry

of firms, demand conditions, relationship between industry and conditionals factors. Government acts as a catalyst, encouraging companies to achieve high levels of competitiveness. This model can be seen in figure 3.

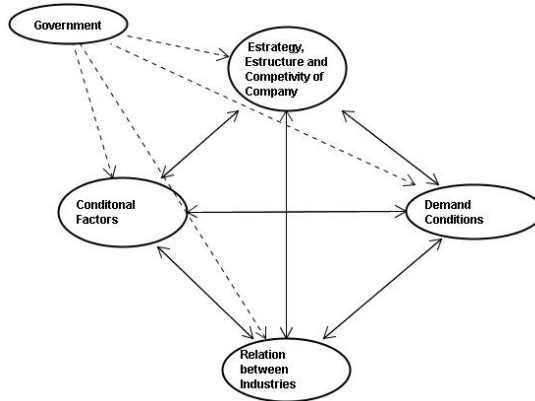


Fig. 3. Potter's National Diamond.

#### 6.4. Triple Helix Model

Triple Helix is a model for transformation processes that involve relationship between government, industry and university. Leydesdorff and Etzkowitz (1998) identify 3 main forms of Triple Helix model.

Triple Helix I model is institutionally defined following spheres: university, industry and government. Organizations such as coalitions industrial, technology disseminators and contractors mediate interaction and boundaries between each level.

Propellers of Triple Helix II are defined as communication systems, formed by operations of markets, technological innovations and control interfaces. Interface between these systems operates in a distributed way, producing new forms of communication.

Institutional spheres of Triple Helix III are university, industry and government. Spheres perform their typical functions. In addition to that they act role of other spheres. Interfaces between these different functions work in a distributed function that generates new forms of communication.

According to Etzkowitz (2002), Triple Helix is a spiral innovation model. It captures multiple and reciprocal relationships between different points in knowledge capitalization process. First dimension of model is internal transformation in each helix. Second is influence of a propeller on other. Third dimension is creation of a new aggregation of trilateral networks and organizations from interaction of 3 propellers. Aggregation aims to create new ideas and formats for development of new technologies.

Dynamism of society has changed from a system based on rigid boundaries separating institutional spheres and organizations, for more flexible system of rotation. Each sphere plays the role of the other in this new system. University becomes a company

founded by stimulating incubators. Industry becomes an educator through corporative universities. Finally, government a bold venture capitalist through programs of research.

These new models are different from model in which institutional spheres are separated from each other, i.e., there is not cooperation or one dominates other spheres, as shown in Figure 4a and 4b, respectively. Currently, there is a migration to model in which spheres alternate in each role and work together, as shown in Figure 4c.

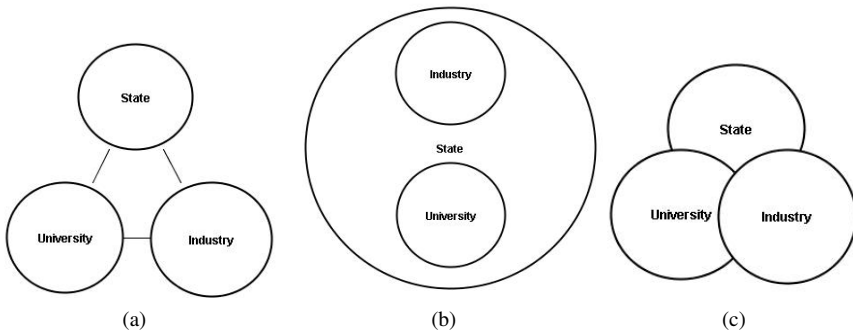


Fig. 4. Triple Helix Models.

## 7. Conclusion

Greater awareness of innovation importance has made it to be included in agenda of most developed countries. Innovation politics results primarily from science and technology policy, but also significant aspects of industrial policies. Substantial changes in development of policies related to innovation have been achieved. It happens due to innovation understand improvement.

High level of competition requires redefinitions of organizational strategies in order to incorporate more cooperation in theirs activities. Technologies change constantly, for this way access to innovation external sources remains critical to continued technological progress. Innovation and networks alignment has great potential for transforming society, besides offering equilibrium to organizations. In doing so, they can build a stability zone in the market.

In Knowledge Age, innovation and knowledge are main factors for nations development. Competitive and dynamics power construction is a way to combat predatory methods of competition, such as low salaries and exploitation of natural resources. For this, it is necessary organizational knowledge growth and innovation process stimulus.

Challenges of organizations to obtain competitive advantages are participation in new markets; enjoy new technological opportunities; improvement skills of its employees and its collection of knowledge and to overcome inertia to seize new opportunities.

Innovations incessantly transform society. In due this dynamism, it is difficult choices an innovation development model to be followed. Cultural, economic and social

characteristics of each region are also factors should be considered. Because they indicate paths and appropriate strategies are not necessarily similar to each region.

Study on innovation networks will be addressed in future work. Studies will aim to identify and assess efficient networks management ways. Survey on use of IT tools to provide support networks innovation. Investigations will specific characteristics of hierarchical and non-hierarchical innovation networks, as well as search improvement ways of management innovation networks. In accordance with this information will propose a model of autonomic innovation networks.

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