

# The Evolution of the Models of Knowledge Management in the Dynamic Business Environment (Cases of the Industrial and Construction Networks in St Petersburg)

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**Abstract:** The paper investigates the process of evolutionary transformation of cooperation and integration modes of industrial and construction enterprises in St.-Petersburg. The period of research (1995-2015) covered three crises in the Russian economy: the crisis after the default of 1998-1999, the global financial crisis of 2008-2009, and the current crisis of 2014-2015. The results obtained enable us to analyze the evolution of the intellectual capital management system in networks, as well as the evolution of networks themselves during changes in the business environment. The network form of integration was chosen as the main object of this research. The paper is aimed at identifying the path of knowledge management development in different types of networks. One of the peculiarities of the network form of integration is the high level of independence of the network participants that interact with each other. Key issues in this cooperation would be the following: How to organize an effective transfer of knowledge and technologies within a network? How to find a balance between open systems of innovation and the protection of the intellectual property of network participants? How to evaluate the intellectual capital of a network? Is it necessary to make an assessment for each participant separately? Should one take into account synergies that increase the value of the intellectual capital because of the network participants' interaction and knowledge sharing? How to increase competitiveness of each company and of the whole network by the effective use of the intellectual capital? How to measure the impact of open innovations on the intellectual capital of the companies interacting within a network? Thus, it is important to reveal how knowledge management system is developing within a network of inter-related enterprises. On the base of interviews of top-managers of companies in industrial and construction companies there were identified five different types of networks and knowledge management systems within these types. It is demonstrated how the knowledge management model is growing and becoming mature from the amorphous type of network cooperation to the integrated type.

**Keywords:** networks, knowledge management, open innovation systems, innovation synergy, capacity for evolution

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## 1. Introduction

Competitiveness of companies in a knowledge-based economic environment is determined by the efficiency of knowledge and intellectual capital management. The possibilities of network cooperation considerably broaden innovation potential of the companies. The Network consolidates intellectual assets, including knowledge, expertise, people resources. Synergy allows the innovation process to be significantly accelerated. The innovation cycle stages are reduced not only by augmentation of the quantitative potential, but by a corporate culture oriented to development and continuous education. The study of network cooperation modes between small, medium and large companies showed that integration can be accomplished in different ways. In these conditions the institutional aspect the management of knowledge and intellectual capital is of interest. We've analyzed different models of network interaction and revealed the main modes of knowledge management system in our article.

## 2. Study methodology

The main purpose of our article is to identify the influence of the network cooperation mode on the knowledge management system architecture. Accordingly we addressed the following problems: study of networks in industry and construction; revealing the mode and stage of integration of network companies; study of the methods and mechanisms of knowledge and intellectual capital management in networks; efficiency assessment of network cooperation in value enhancement of intellectual capital. The main methods of our study are observation, interview, information analysis and synthesis, and logical and mathematical simulation. The basic concept adopted in the study is the open innovation concept theoretically based by Chesbrough, Vanhaverbeke and West (2003). In the article "Open innovation: The next decade" presented by West, Salter, Vanhaverbeke and Chesbrough (2014) 10 years of this approach were summarized. The authors confirmed the efficiency of this business model in the current conditions. At

the same time the authors identified some problems. Open innovation presents the problem of interested parties' relationship within the network and out of it. The open innovation problems in the context of the SME's networks was developed by Lee, G. Park, Yoon and J. Park (2010), Drechsler and Natter (2012), Okatan (2012), Gnyawali and Srivastava (2013,) Tomlinson and Fai (2013). As noted by Rogo et al. (2014), open innovation efficiency is defined by several factors, including the level of development of legislation and availability of highly qualified personnel. Those factors enable the interests of the network parties to be protected. The process of network formation has a heuristic nature. By its nature, a network is the structure formed on the basis of cooperation between companies in the process of creating a certain product. Having said that, it must be noted that the scales of network structures essentially depend on the specifics of the core process for the creation of the end product.

Networks intrinsically possess all the benefits provided by economic integration based on cooperation.

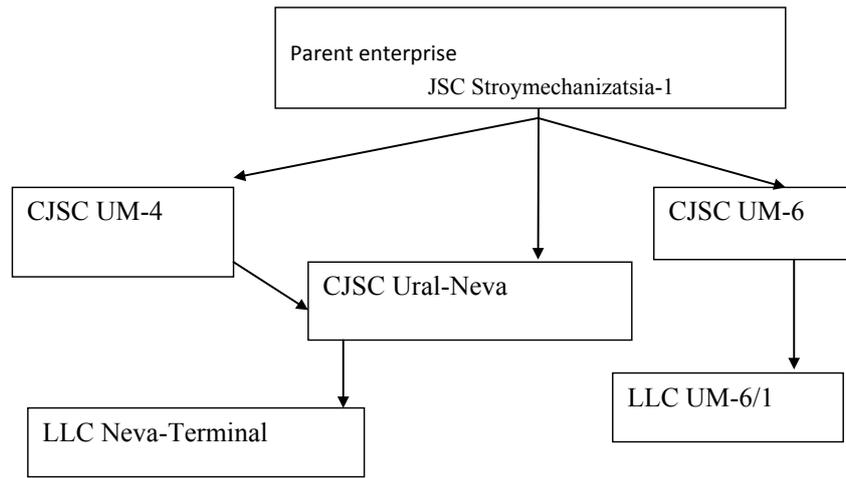
Let us analyze the cooperative interactions within a network. The basis for assessment of the impact of cooperation is the discovery of the primary mechanisms which implement cooperative interactions. A similar analysis of the mechanisms for the whole complex of small enterprises was carried out in the research paper by Yegorova and Marennyi (2002). We think expedient to extend and complement the list of mechanisms revealed, taking account of the specific nature of cooperation within a network.

These include the following:

- A cost and distribution mechanism ensuring optimum utilization of production capabilities for all companies taking part in the process of cooperation on the basis of subcontracting and outsourcing. At the same time, joint use of information and manufacturing resources may serve as a tool with a view to optimizing the costs of all participants of the cooperation process.
- A loan and cooperation mechanism with the utilization of network participants' reciprocal loan facilities, as well as mutual guarantees and sureties in case of stable and long-term cooperation. A network may include production facilities, as well as financial and investment companies, investment banks and leasing companies.
- A tax optimization mechanism. It presupposes legitimate methods, as well as illegitimate ones, to be used as a basis for reducing taxes. Tax problems, as faced by financial management of the companies that make up the network, are partially solved by conducting operations that facilitate the use of schemes aimed at reducing the burden of taxation (Proskura, 2007).
- An innovation mechanism. It presupposes the use of technological transfer on preferential terms for the network participants (including franchising elements), as well as research and development cooperation.
- An information mechanism. It has two aspects. A marketing mechanism brings an opportunity for all cooperation process participants to use the advantages of a well-known brand. A communication mechanism presupposes the formation of a common information space to ensure efficient communications.
- Each major network can be a system of minor networks engaged in competition with each other on a limited regional market; however, they may combine efforts, when externally influenced, for instance to enter national and international markets.

### **3. Network model study: The cases of the industry and construction networks of St Petersburg, Russia)**

Our study of the networks in industry and construction of St Petersburg is being conducted from 1998 till nowadays. Market transformation of the Russian economy on the first stage led to disintegration of companies, primarily in industry. Long-term cooperation connections were destroyed. The process of segmentation of production associations occurred rapidly; for instance in 1991 there were more than 5,500 engineers and production workers at the Northern (Severny) plant, and the plant had its own development bureau. By 2002 there were less than 500 workers left on the plant. All production enterprises suffered this trend. The process of recovery and development of cooperation networks was slow. The general decline in industry hampered economic development of separate enterprises. Quasi-holdings became the main form of the network during this period. Quasi-holdings were formed in the process of restructuring of the large enterprises. The process of separation of small and medium enterprises from their structure led to a loss of control. Management endeavoured to save the remains of the industrial potential and formed holding ventures. The model of the quasi holding, JSC Stroymechanizatsia-1, is shown in fig. 1.

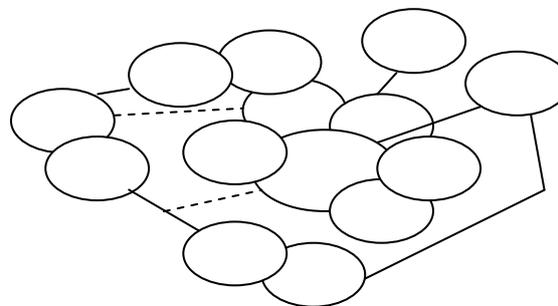


**Figure 1:** The interconnection structure in the quasi holding, JSC Stroymechanizatsia-1

In these conditions, the knowledge-based SME sector grew rapidly. The employee development, innovation, customer satisfaction and organizational success were the areas where small and medium-sized businesses benefited from knowledge management activities (Edvardsson and Durst, 2013).

**3.1 Case 1: The amorphous networks. Proto-cluster of SME in construction industry (St. Petersburg)**

The process of rapid development of the networks began during the recovery period of the Russian economy. Moreover a lot of cooperation connections were informal, networks did not have a clearly defined architecture, and a great number of network participants did not have clearly defined boundaries. Accordingly, those networks were difficult to research. The only way to analyse network cooperation is an interview. Studies we conducted showed us that frequently those networks had the certain coordinate authorities, which defined the strategy of the network development. The main method of knowledge transfer in those networks is replication, legal as well as illegal. A knowledge management system is practically non-existent and intellectual capital essentially underestimated. This condition of the knowledge management system can be defined as amorphous (fig.2)



The Connection's character



**Figure 2:** The amorphous network

From an interview (2010) of the director of the company participating in the divisionalisation of a cooperating network in the construction industry: “I don’t need qualified workers. They cost too much. To teach migrant worker to tighten a screw you only need one hour – and let him go and work. The engineers just have to design the projects; they were taught that in university, you don’t have to teach them”. However under the influence of the changed circumstances transformation of such networks occurs very quickly. The company described teamed up with a large network, which develops new technologies for construction assembling on the open innovation platform. From the interview with the same director (2013): “Everyone went to learn. I myself went abroad for training four times in the last year. We need

to adapt these technologies to Russian conditions first, otherwise we will be pushed (out of the market) by competitors. The only problem is with the good workers. We will educate our own”.

### 3.2 Case 2: “The technological daisy”. The metal fabrication industry cluster

Most common models of the structured networks are vertically and horizontally integrated companies.

Horizontally integrated companies, which have common business profile, build their knowledge management system on the principles of a competency building approach. The variant of a technology transfer centre is a technology competence centre – hi-tech production, which every network participant uses as a production unit and educational centre, allowing the technology level to rise rapidly. In 2008 for description of architecture of such networks by P. Plavnik and K. Soloveychik suggested the term “technological daisy” (fig.3)

Presently this centre is acquiring the characteristics of a full-scale research subdivision and participates in the development process of a new diesel unit. A wide range of the companies is participating in this work, and development is conducted on the principles of open innovation. This was prompted by the complexity of the problem. In the assessment of general director JSC Zvezda, P. Plavnik, organizer of the metal fabrication industry cluster, “the level of the losses of engineering competence ... allows us today to invest in the new diesel intellectual product at a level of only 20-30% of the investment required for the creation of a new diesel”.

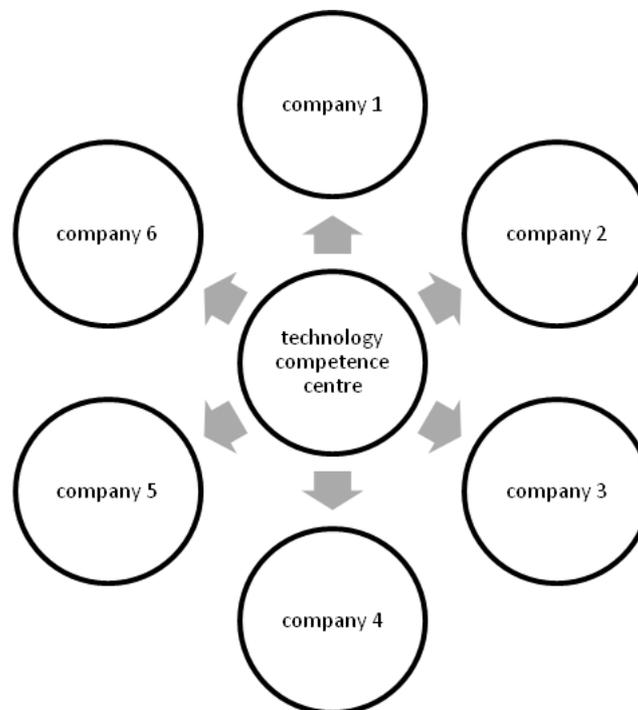


Figure 3: Knowledge management structure in a metal fabrication industry cluster

### 3.3 Case 3: “The technological funnel”. Polymer cluster of St Petersburg

A graphic example of the horizontal integration of enterprises, research organisations, commercial structures and engineering firms is the polymer cluster. This cluster was built around a scientific problem, the solution of which has great commercial potential. The problem of development of a polymer coating with particular characteristics united a great circle of participants. Working as an open innovation network this cluster successfully commercialized a range of side products, which resulted from solving the main problem. The functional model of this cluster is shown in fig. 4.

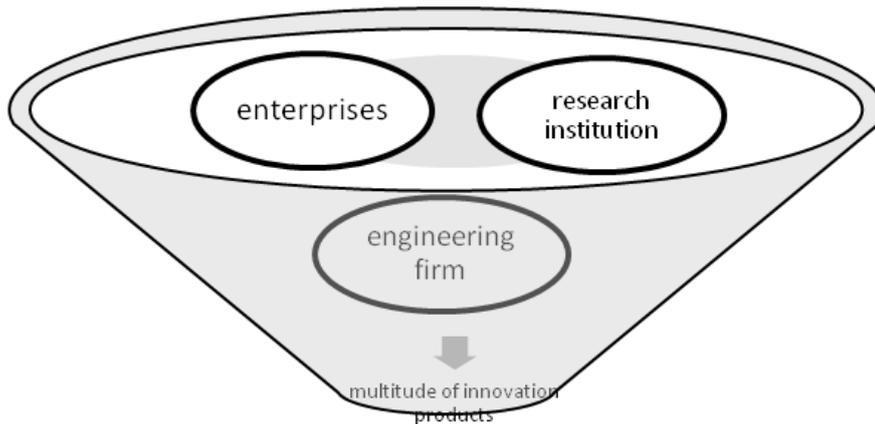


Figure 4: Network-funnel model (Polymer cluster of St Petersburg)

**3.4 Case 4: The integrated networks. Transport engineering cluster “Metrodetal” (St Petersburg – Tikhvin – Saratov)**

Integrated networks, as a rule, unite organizations connected by subcontracting and outsourcing contracts. Such type of networks are characterized by the tendency to vertical integration. Without a large enterprise, which could assume the core functions, the special subdivision is formed. This subdivision assumes the functions of the parent company. For instance, a transport engineering cluster develops this way. The cluster management structure is shown in fig. 5.

As you can see on the schematic shown, in this network the system of knowledge and intellectual resources management is developed and all the companies of the cluster implement a common innovation policy. At the same time the innovation process involves external organizations when this meets the interests of the cluster development. This cluster gradually undergoes the process of transformation into a corporation, which poses a question on institutional aspects of network development.

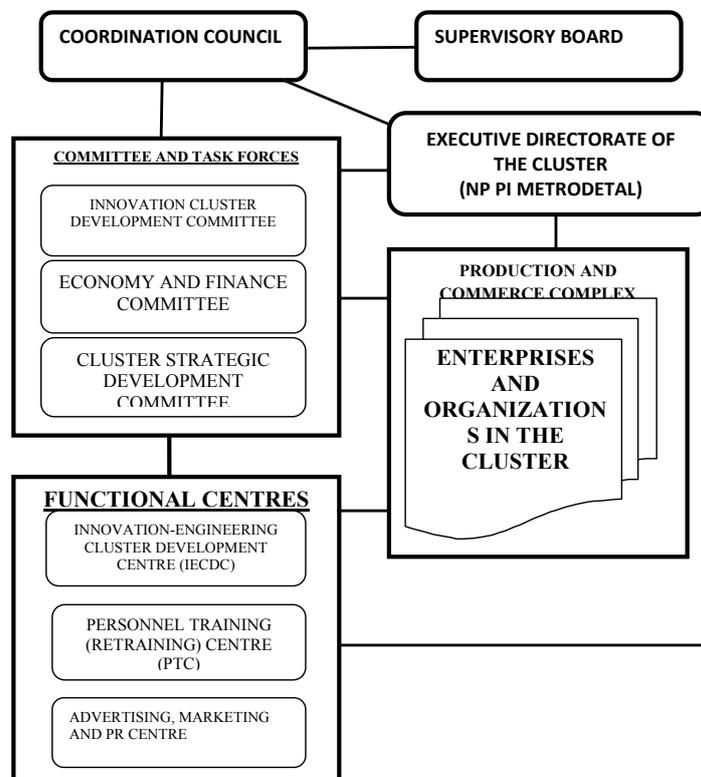
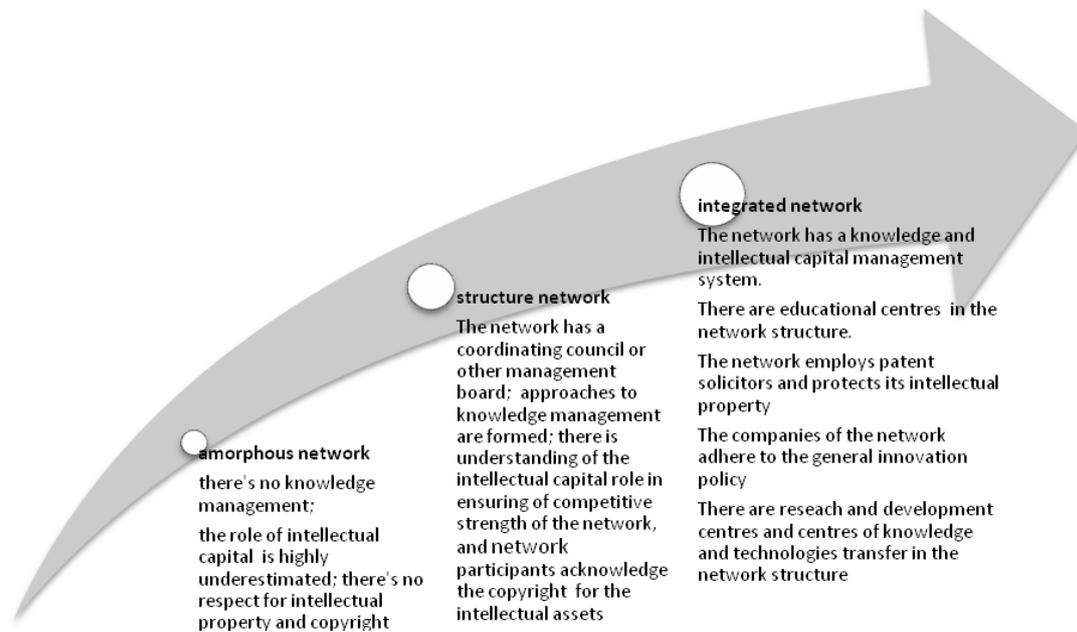


Figure 5: “Corporate” structure of the transport engineering cluster “Metrodetal”

The transformation process of the knowledge management in networks as they develop is shown in fig. 6.



**Figure 6:** The development process of the knowledge management system in networks

#### 4. Institutional problems of the network development in the Russia

From an institutional point of view the network development process can be completed by the process of vertical, horizontal or heterogenic integration into a holding or cross-holding structure. Consequently, the open innovative systems are characterized by the features inherent to the network organizations. And the companies that decide to use this business model have to address an open question about the level of innovation synergies generated by the network interaction. Isn't an open innovation system worse than a closed one, such as existing in the vertically integrated corporation?

The problem of the comparative effectiveness of cooperation of independent companies and vertical integration was defined, for example, in the works by Kapitonenko (1994), Jacobides, Knudsen and Augier (2006), Tkachenko (2007).

We believe that a similar approach can be implemented to the analysis of the benefits of open innovation systems that use acquired intellectual capital.

The likelihood of a successful transition from one R&D phase to the next one for the organization of non-integrated participants in the innovation process is determined by several factors such as:

- the level of supply and demand for an innovative product;
- the correlation between market and contractual prices;
- the communication effectiveness;
- the duration of parallel and sequential steps;
- the stability of relations between the participants of the innovation system;
- the degree of solvency of the end user;
- the degree of scarcity of consumed resources, etc.

The probability that a failure may occur at any stage of the innovation cycle increases with the unfavourable scenario. Naturally, the probability of deviation from the performance time is less and determined by the probability of performance by each division of the research or production programme within a vertically integrated corporation in the context of complete dependence of research and production departments on the administrative centre. There exists a possibility of information leakage within the corporation in the early stages. However, the level of information security will be significantly higher than in the union of non-integrated companies because of the strategic management unity realized through a system of bilateral long-term contracts.

To get quantitative estimates, we consider the full innovation cycle where each result  $i$  is used to get the following result  $(i + 1)$  with a certain expenditure ratio  $a_{i(i+1)}$ . Let us suppose as a first step that the companies involved in the development process and companies that produce prototypes are organizationally independent. In this case, each  $i$  result theoretically has its market  $R_i$ , the subjects of which are vendor - manufacturer of the product or result  $i$   $S_i$  and the consumer of  $i$  product or result – the manufacturer of the product  $(i + 1)$  -  $S_{(i+1)}$ :

$$S_1 \rightarrow R_1 \rightarrow S_2 \rightarrow R_2 \rightarrow \dots \rightarrow S_{n-1} \rightarrow R_{n-1} \rightarrow S_n \rightarrow R_n, \quad (4.1)$$

where  $n$  is a final product. Thus the open innovation system may experience adverse results of research and development that lead to the creation of an additional final innovation product. In this case (1) takes the following form:

$$S_1 \rightarrow \{R_{11}; R_{1r}\} \rightarrow \{S_{21}; S_{2m}\} \rightarrow \{R_{21}; R_{2r}\} \rightarrow \dots \rightarrow \{R_{n1}; R_{nm}\} \quad (4.2)$$

The effectiveness of the innovation process for the project participants will be determined not only by the success of the implementation of the planned end-product  $N$ , but also by the results of the implementation of side projects. In that way, from the point of view of the participants, the effectiveness of the open innovation system will be different from the effectiveness of a closed system as follows (3):

$$\Delta E = E(\{R_{n1}; R_{n2}\}) - E(R_n), \quad (4.3)$$

where  $E$  is a function of the effectiveness of the final products of the innovation process.

Consequently, it is obvious that an open innovation system has a higher potential for efficiency compared to a closed one, even without considering the results of the qualitative parameters of the innovation process; but the involvement of the external intellectual capital also entails certain risks related to the inability to secure the rights to the intellectual property at some stage that the interpreters of the model do not take into account (Plotnikov, Sobolev, 2012).

The problem of choosing the form of institutional integration from a theoretical point of view comes down to the problem of control of ownership. According to the logical comparative analysis of efficiency of formal and informal integration, other factors are not crucial. In the stable cooperation network stability of supply is provided on the same high level as in a corporation. However in the Russian Federation cluster policy pushes networks and clusters towards the corporate form of integration. To ensure authorities support for the cluster it is necessary for the management company of the cluster to register with the government as a non-commercial partnership, which contradicts the purpose of commercial efficiency of the cluster. Networks and clusters reviewed above do not exist from official St Petersburg statistics and city authorities' point of view. There is no information about those clusters on the web-site of Industrial Policy and Innovations Committee of St Petersburg administration. In fact there are more than 25 networks and clusters operating in the city in different spheres, while according to official data there are only 5, and notably only one cluster receives support - the pharmaceutical cluster.

One more reason for many networks to choose the corporate form of integration is to receive the access to the public procurement system. For a large joint stock company it is easier to receive a government order than for a small or medium-sized company or for a partnership of such companies. Now, according to the new public procurement law, discrimination against small and medium-sized enterprises is prohibited, but in fact it's difficult for SMEs to compete with large enterprises in open tender conditions.

## 5. The problem of the capacity for evolution of knowledge and intellectual capital management systems in innovation networks

The number of network units may be quite considerable, just as the number of enterprises making up the system. In this case, we are dealing with proactive cooperation initiated by economic agents in order to improve the competitiveness of each participant in the network, based on benefiting from the synergetic effect provided by the interaction of elements of the network system.

Consequently, it is possible to use mechanisms facilitating the formation of network structures at the level of regional management. In this case, reactive cooperation will take place; that is, formation of networks must be the reaction of a regional economic system to changes in business environment in the form of opening the door to development of

networks in the thematic priorities of business activities. The research revealed direct interrelation between the way a network is formed and its further capacity for evolution.

Let us consider the factors giving rise to network structures.

- Increased competition that resulted in the formation of stable long-term cooperation;
- Changes in business environment (tax, legislative, political, and other changes), that increase the effectiveness of performance of associations of enterprises;
- Outside pressure on a sector of the economy, requiring a combination of efforts to successfully resist the pressure;
- Introduction of new technologies that precondition the spontaneous formation of association of enterprises based on core technology;
- The need for scientific and technical cooperation in technology intensive sectors of the economy.

Networks that are proactive in nature have the capacity for self-development. Cooperation brought about for economic reasons was the basis for their formation. At a later stage, when influenced by the change in external conditions, these networks manifest a high degree of adaptiveness. The more complex the conditions, the more structured amorphous networks become, and the higher is the probability of network transition to hierarchic interaction and to the formation of quasi holdings. The intellectual asset management system then becomes one, ensuring effective transfer of knowledge, technological development, employee training and education and, as a consequence, improved competitiveness. As the external pressure is reduced, the degree of organization may become lower. In some cases, degradation or transformation of the network may be observed.

According to our research, networks formed under the reaction principle, as a consequence of the stimulating impact from regional authorities, are far from being able to evolve. As a rule, they are initially grouped around technology (technological daisy), or around a core task (technological funnel). The reaction of those networks to changing basic conditions is to seek external assistance and support, in the first instance, from local authorities.

## **6. Conclusion**

The research enabled us to organize the types of knowledge and intellectual capital management systems in innovation networks. Our research revealed two factors influencing the evolution of knowledge management within networks.

First, we identified a direct correlation between the network structuring level and the development of a knowledge management system. Task-oriented knowledge and intellectual capital management does not depend on the scale of the network or on the size of participating enterprises. Evolution of models of knowledge management in networks directly depends on degree of rigidity of cooperation communications. Indistinct, soft networks usually use intuitive methods of knowledge management. The structured networks aspire to ordered and organized models of knowledge management. The changes of environment influence the speed and the direction of evolution process. Awareness of the need of knowledge management development is dictated by competition strengthening.

Second, and this is a practical contribution of this study, it revealed direct interrelation between the way a network is formed and its further capacity for evolution. Proactive way of networks forming provides more possibilities for evolution of knowledge management within networks. Thus, the competition and the way of networks forming cause evolution of knowledge management in networks.

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