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The evolution of the models of the knowledge management within networks (Cases of the industrial and construction networks in St Petersburg)

Abstract: The paper investigates the process of evolutionary transformation of cooperation and integration modes of industrial and construction enterprises in St.-Petersburg. The study has been performed at the period since 1998 to nowadays. 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. Factors, influencing this evolutionary development, have been revealed. Also, the paper proposes an approach to the evaluation of knowledge management systems based upon the value-based management indicators.

Keywords: networks, knowledge management, open innovation systems, innovation synergy, market value added.

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 H. Chesbrough, W. Vanhaverbeke, J. West (2003). In the article "Open innovation: The next decade" presented by Joel West, Ammon Salter, Wim Vanhaverbeke, Henry 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 Sungjoo Lee, Gwangman Park, Byungun Yoon, Jinwoo Park (2010), Wenzel Drechsler, Martin Natter (2012), Kagan Okatan (2012), Devi R. Gnyawali, Manish K. Srivastava (2013,) Philip R. Tomlinson, Felicia M. Fai (2013). As noted by F. Rogo and all (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 other problem is assessment of the efficiency of open innovation. Modern researchers suggest solving this problem within the framework of value management concept (Yuandi Wang, Wim Vanhaverbeke, Nadine Roijackers (2012) Francesco Rogo, Livio Cricelli, Michele Grimaldi (2014). We share this opinion and suggest assessing the efficiency of cooperation based on the changes in the value of the network intellectual capital.

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 the present day. Market transformation of the Russian economy on the first stage led to disintegration of the 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 fewer 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.

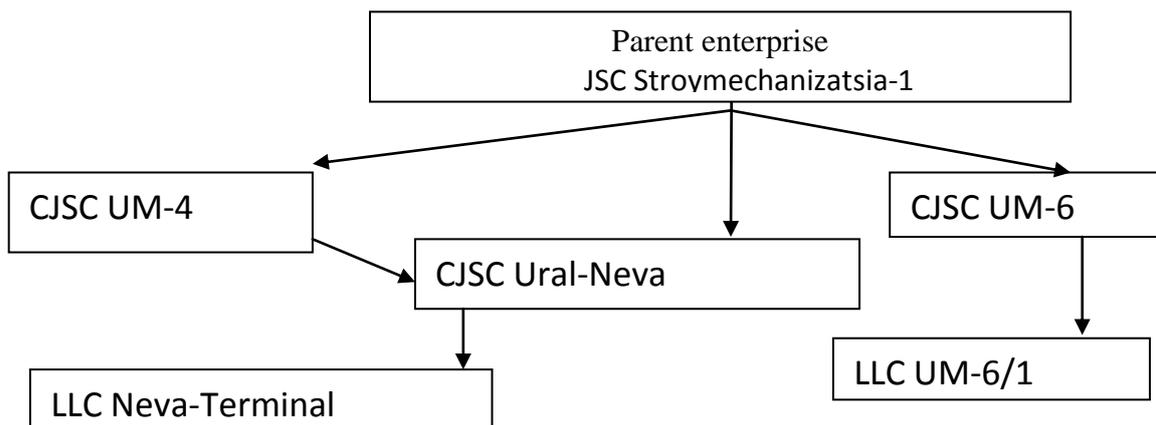


Figure1. The interconnection structure in the quasi holding, JSC Stroymechanizatsia-1.

In this conditions the knowledge-based SME sector grew rapidly. The employee development, innovation, customer satisfaction and organizational success as areas where small and medium-sized businesses benefit from knowledge management activities (Ingi Runar Edvardsson, Susanne 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)

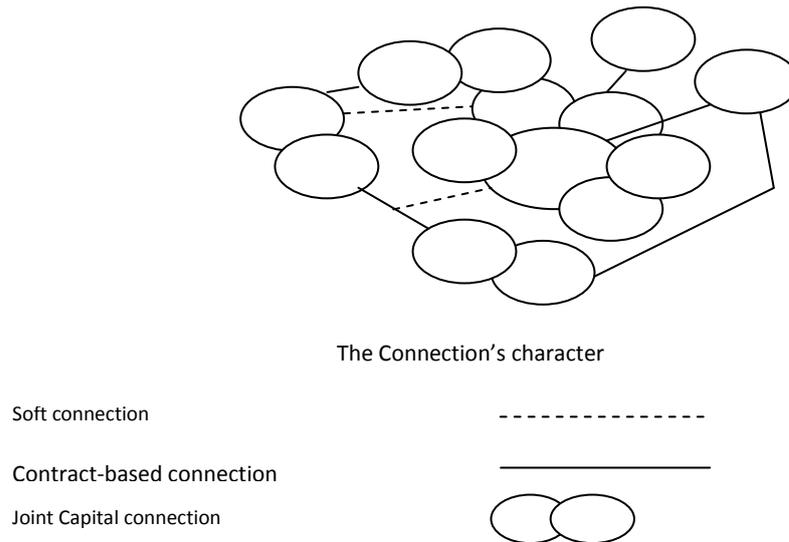


Figure 2. The amorphous network

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)

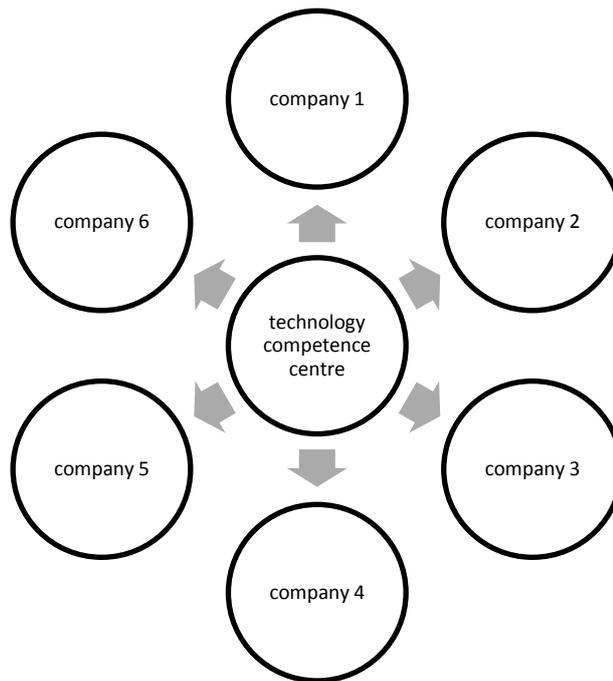


Figure 3. Knowledge management structure in a metal fabrication industry cluster.

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”.

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.

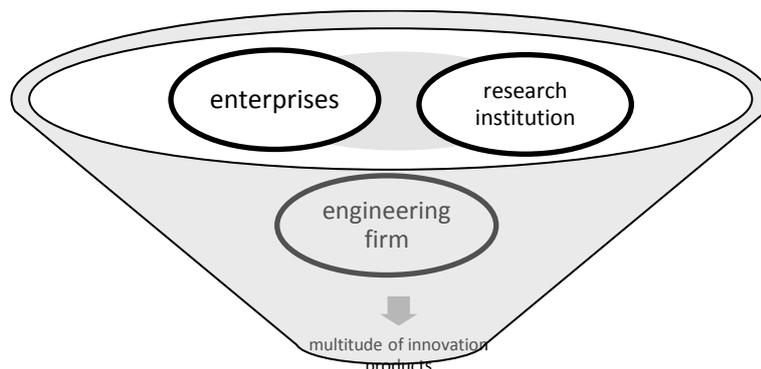


Figure 4. Network-funnel model (Polymer cluster of St Petersburg)

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.

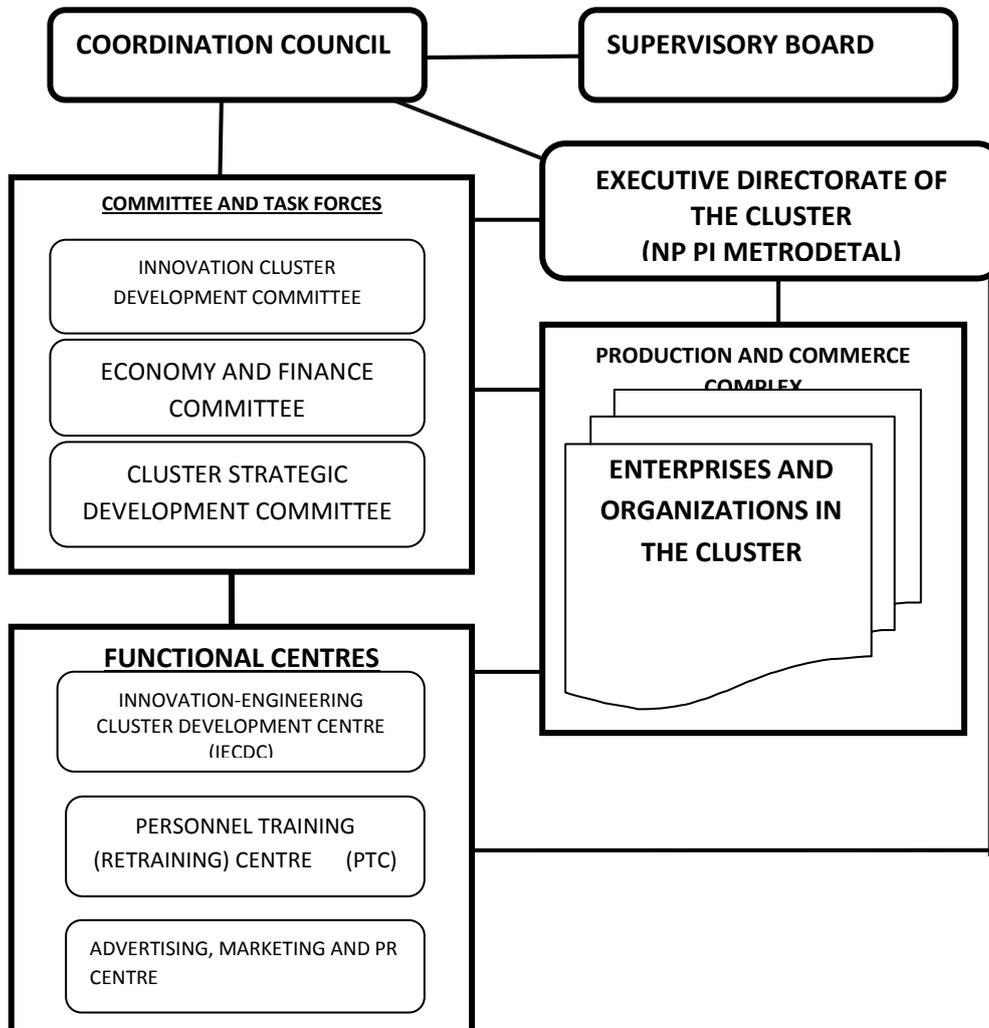


Figure 5. "Corporate" structure of the transport engineering cluster " Metrodeta".

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

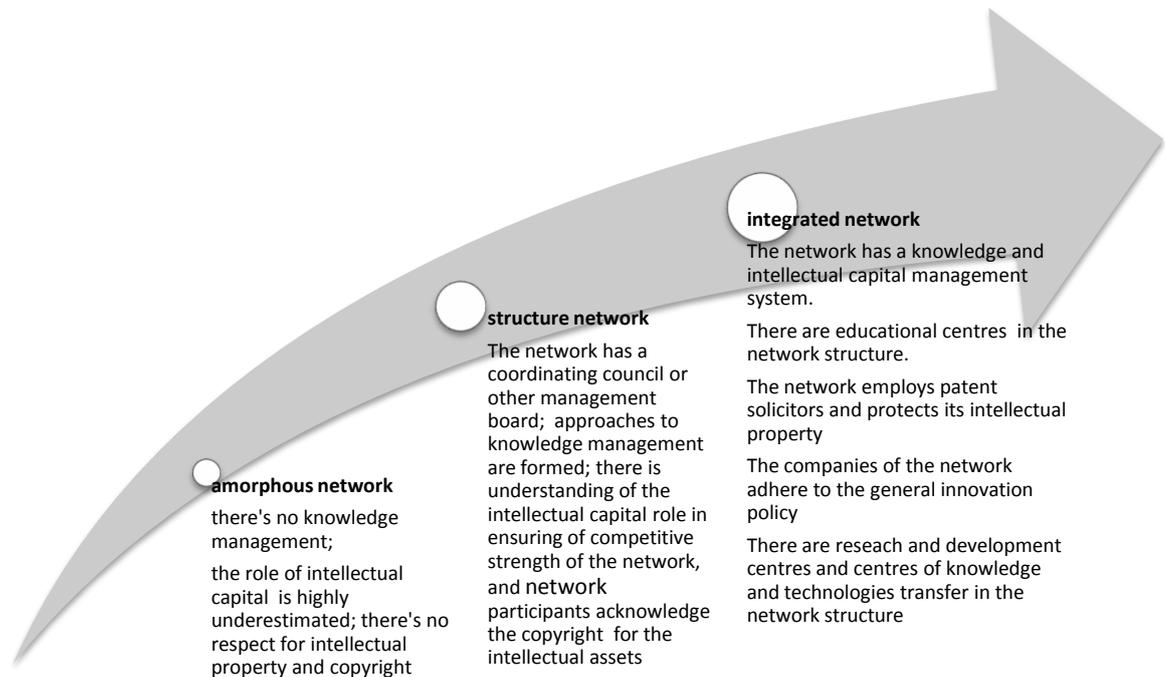


Figure6. The development process of the knowledge management system in networks.

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 of V. Kapitonenko (1994), Michael G. Jacobides, Thorbjørn Knudsen, Mie Augier (2006), E. Tkachenko (2007).

We believe that a similar approach makes it possible to analyze 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 of 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 (B.D. Plotnikov, A.S. 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 efficiency of knowledge management in the networks

In their turn, quantitative effects are determined not only by the profitability of a new product after entry into the market (direct financial result), but by other possibilities of implementing an innovative product created in the open innovation system. It can take the form of licensing, spin-offs, sale of part of a business, the use of intellectual property as an investment resource for creating a new business, etc. This approach that takes into account the multiplier effect resulting from the open innovation systems was used, for example, by V.V. Platonov (2010). The value-based approach was developed by Michael G. Jacobides, Thorbjørn Knudsen, Mie Augier (2006), Stephen Roper, Jun Dub, James H. Love (2008), Jon-Arild Johannessen, Bjorn Olsen (2010), Aron O'Cass, Phyrá Sok (2013).

According to the value approach of management formal vertical integration creates the background for increasing the overall value of companies by means of the influence of systemic synergy factors. At the same time the situation appears to be totally realistic, where separate companies can ensure higher increment of value during the period by the means of greater flexibility and adaptability in the management of intangible assets. As a result, the cluster form of innovation integration can have advantages compared to development of vertically integrated companies.

Let us analyse construction of the function of the innovation synergy under the conditions of open innovation networks.

$$f(S) \rightarrow \max,$$

$$S = \sum_{t=1}^T \frac{MVA_t + \delta_{tT} Q_t}{1 + r^t} \quad (5.1)$$

where MVA_t – extended consolidated market value added in the year t ;
 Q_t – extended balance sheet assets;
 δ_{tT} - Kronecker delta:

$$\begin{cases} 1, & t = T, \\ \delta_{tT} = 0, & t \neq T \end{cases}$$

$$MVA_t = \sum k_{mt} (MVA_{mt}), \quad (5.2)$$

MVA_{mt} – added market value of the company – network participant in the year t ; k_{mt} – balanced (rank) coefficient, reflecting involvement of the company in the network;

$$Q_t = \sum k_{mt} (Q_{mt}), \quad (5.3)$$

where Q_{mt} – balance sheet net assets of the company – network participant in the year t .

There are the following limitations in the specified optimization model:

MVA_{mt} is defined by the efficiency of the innovation activity of subsidiary companies and by the quality of the intangible assets management.

Consequently value function of innovation synergy can be used for both analysis of integration efficiency and for prognosis of strategic directions of an innovation network.

The key problem in employing this model is the problem of defining the market value added for non-public companies. We solved this problem on the basis of the regular evaluation of capitalized value of the companies, involved in the network. For this purpose we have used baseline model of a firm's value:

$$V_t = \frac{NOI_t}{CR_t} \quad (5.4)$$

where V_t - firm's value in the year t

NOI_t - net operating income of the firm in the year t

CR_t - capitalization coefficient (industry rate of return) in the year t

Table 1 presents data for the two periods of the operating of the network of the construction enterprises, reviewed in section 3.1. Five companies of this network with the highest involvement in the network were included in the study. Year 2010 – there is no innovation activity; year 2013 – the companies are involved in the open innovation system.

Table 1. Data for the network of the construction enterprises (2010, 2013)

	V_t , thousands roubles		Q_m thousands roubles		Involvement coefficient, %	
	2010	2013	2010	2013	2010	2013
Firm 1	20000	32000	21200	24000	100	100
Firm 2	12350	15200	12000	13200	80	100
Firm 3	15700	17000	15500	13000	75	75
Firm 4	18100	26000	19000	21000	45	75
Firm 5	5000	12650	5000	7000	20	80

Thus, the added capitalized value with provision for the involvement coefficient amounted to 27 million 870 thousands of roubles, and the increase of assets value for the same period amounted to 5 million 225 thousand of roubles. Additionally the highest increment of capitalized value was observed in the parent company and in companies, whose involvement in the network has risen sharply.

MVA changes for each company are shown in table 2 .

Table2 - MVA changes 2010 -2013, thousands of roubles

	MVA 2010	MVA 2013	Δ MVA 2010/2013
Firm 1	-1200	8000	9200
Firm 2	350	2000	1650
Firm 3	200	4000	3800
Firm 4	-900	5000	5900
Firm 5	0	5650	5650
Total Δ			26200

It is obvious that all the companies have increased their value. Now all the companies have the positive value of intangible assets. Thus, cooperation, deepening on the basis of methods of knowledge management use, is accompanied with the growth of business value. This method of evaluation is simple, clear and easily applicable even for the non-public companies. Our research revealed that the companies' management perceives this model quite well. The advantage of this method also is the simplicity of results interpretation.

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, the companies' management needs in simple and clear methods of evaluation the cooperation efficiency. The adequate assessment stimulates evolution of knowledge management within networks. Thus, the competition and the possibility to estimate the effect from cooperation cause evolution of knowledge management in networks.

References

- Chesbrough, H. (2003) Open Innovation: The New Imperative for Creating and Profiting from Technology HBS Press, 2003
- Drechsler, W., Natter, M. (2012) Understanding a firm's openness decisions in innovation. Journal of Business Research, Volume 65, Issue 3, March 2012, Pages 438-445
- Gnyawali D.R., Srivastava, K.M. (2013) Complementary effects of clusters and networks on firm innovation: A conceptual model. Journal of Engineering and Technology Management, Volume 30, Issue 1, January–March 2013, Pages 1-20
- Jacobides, M.G., Knudsen, T., Augier, M. (2006) Benefiting from innovation: Value creation, value appropriation and the role of industry architectures Research Policy 35 (2006) 1200–1221

Johannessen J.-A., Olsen, B. (2010) The future of value creation and innovations: Aspects of a theory of value creation and innovation in a global knowledge economy. *International Journal of Information Management* 30 (2010) 502–511

Kapitonenko V.V. (1994) The advantages of vertical integration in the formation of organizational and production systems (model analysis), // *Russian Economic Journal*, 1994 - No. 10

Lee, S., Park, G., Yoon, B., Park, J. (2010) Open innovation in SMEs—An intermediated network model. *Research Policy*, Volume 39, Issue 2, March 2010, Pages 290-300

Michael A. Stanko, M.A., Olleros X. Industry growth and the knowledge spillover regime: Does outsourcing harm innovativeness but help profit? *Journal of Business Research*, Volume 66, Issue 10, October 2013, Pages 2007-2016

O’Cass, A. Sok, P. (2013) Exploring innovation driven value creation in B2B service firms: The roles of the manager, employees, and customers in value creation. *Journal of Business Research*, Volume 66, Issue 8, August 2013, Pages 1074-1084

Okatan, K. (2012) Managing Knowledge for Innovation and Intra Networking: A Case Study/*Procedia - Social and Behavioral Sciences*, Volume 62, 24 October 2012, Pages 59-63

Platonov V.V. (2009) Approaches to the financial evaluation of projects participating in an open innovation platform. St. Petersburg, 2009

Plotnikov., B.D., Sobolev A.S. (2012) Problem of Synergy in Open Innovation Systems./ *Economic Science*, 2012 - No.1

Rogo F., Cricelli, L., Grimaldi M. Assessing the performance of open innovation practices: A case study of a community of innovation. *Technology in Society*, Volume 38, August 2014, Pages 60-80

Ropera, S., Dub, J., Love, J.H., (2008) Modelling the innovation value chain. *Research Policy* 37 (2008) 961–977

Sok P., O’Cass, A. Sok, K.M (2013) Achieving superior SME performance: Overarching role of marketing, innovation, and learning capabilities. *Australasian Marketing Journal (AMJ)*, Volume 21, Issue 3, August 2013, Pages 161-167

Tkachenko E.A. (2007) Theoretical and Methodological Background to the Management of Integrated Development of a Company. St. Petersburg, Publishing House FINEC, 2007

Tomlinson, F.R., Fai, M.F. (2013) The nature of SME co-operation and innovation: A multi-scalar and multi-dimensional analysis. *International Journal of Production Economics*, Volume 141, Issue 1, January 2013, Pages 316-326

Wang, Y., Vanhaverbeke, W., Roijakkers, N. Exploring the impact of open innovation on national systems of innovation — A theoretical analysis. *Technological Forecasting and Social Change*. Volume 79, Issue 3, March 2012, Pages 419–428

West, J., Salter, A., Vanhaverbeke, W., Chesbrough H. (2014) Open innovation: The next decade. *Research Policy*. Volume 43, Issue 5, June 2014, Pages 805–811