STUDY AND ASSESSMENT OF THE STRUCTURAL CAPITAL OF AN INNOVATION INDUSTRIAL CLUSTER

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Abstract

The relevance of this study is underscored by the intellectualisation of industrial and business processes, the growth of the knowledge intensity of products, and the increased complexity of organisational interaction between economic entities. This study aims to formulate the concept and assess the structural capital of an innovation industrial cluster on the basis of the developed methodology. The object of the study is the structural capital of the innovation industrial cluster "Development of information technologies, radioelectronics, instrumentation, and means of communication and infotelecommunications of Saint Petersburg". Using various research methods, including observation, surveys, questionnaires, analysis, synthesis, and mathematical modelling, the study focuses on the process of assessing the structural capital of the innovation industrial cluster. This paper presents a study of the types of intellectual capital of an innovation industrial cluster that analysed the internal and external environment of the cluster. We designed a methodology for assessing the structural capital of the innovation industrial cluster and assessed the structural capital of the innovation industrial cluster, providing recommendations for its development based on the study's findings. Future research should focus on the development of theoretical, methodological, and practical provisions for assessing the capital of innovation industrial clusters. Insights from this study can inform management decisions in innovation clusters and enterprises when evaluating intellectual property.

ИССЛЕДОВАНИЕ И ОЦЕНКА СТРУКТУРНОГО КАПИТАЛА ИННОВАЦИОННО-ПРОМЫШЛЕННОГО КЛАСТЕРА

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Аннотация

Актуальность исследования обусловлена интеллектуализацией промышленных и бизнес-процессов, ростом наукоемкости выпускаемой продукции и усложнением организационного взаимодействия хозяйствующих субъектов. Цель работы – сформулировать понятие и провести оценку структурного капитала инновационно-промышленного кластера на основе разработанной методики. Объектом исследования является структурный капитал инновационно-промышленного кластера «Развитие информационных технологий, радиоэлектроники, приборостроения, средств связи и инфотелекоммуникаций Санкт-Петербурга». Предметом исследования выступает процесс оценки структурного капитала инновационно-промышленного кластера. Методы исследования, примененные в работе – наблюдения, опроса и анкетирования, анализа и синтеза, математического моделирования. В работе представлено исследование видов интеллектуального капитала инновационно-промышленного кластера. Проведен анализ внутренней и внешней среды исследуемого кластера. Предложена методика оценки структурного капитала инновационно-промышленного кластера. Проведена оценка структурного капитала инновационно-промышленного кластера. На основе полученных результатов даны рекомендации по его развитию. Направлением дальнейшего исследования является развитие теоретическо-методологических и практических положений, по оценке капитала инновационно-промышленного кластера. Представленные материалы могут быть использованы при принятии управленческих решений в инновационных кластерах и предприятиях, при проведении оценки интеллектуальной собственности.

Ключевые слова: кластерные объединения, инновационно-промышленный кластер, интеллектуальный капитал, структурный капитал, стоимость

1. Introduction

Today, great hopes are placed on cluster associations for developing Russia's economy to strengthen its competitiveness in the world arena. An analysis of cluster development in Russia shows that there are problems and significant growth potential, making the study of cluster formations relevant (Babkin et al., 2020; Druzhinin and Alekseeva, 2020; Saadatyar et al., 2020). The modern sustainable development of industries is accompanied by constant technological and product improvement (Babkin et al., 2021), which leads to an increase in added value due to the intellectual component. The intellectual component can provide a competitive advantage that determines the interest in its research (Zaytsev et al., 2020). To date, research on value creation through intellectual components has been conducted using the theory of intellectual capital (Vetrenko et al., 2017). The theory of intellectual capital is used in studies of various industries. Here, intangible assets of various kinds and their influence on all functions of the management of economic entities are investigated.

Due to the large number of very heterogeneous assets within the framework of intellectual capital, the different types of capital included in it are investigated. The most actively studied is human capital (Yeoh, 2008) which is a constituent part of intellectual capital. Recently, studies of social capital, which was adopted into economic science from social disciplines, and network capital, which is associated with the development of internet interaction, have been actively developed. Less attention is paid to intellectual property at all stages of its life cycle, which forms structural capital. We consider this an omission because it increases the dependence on the human factor, the management of which is the riskiest. The development of cluster formations, their special role in the development of the Russian economy, and the tasks entrusted to their development stimulate the need to study the theory of intellectual property management, which has not been given enough attention recently. Thus, the purpose of this study is to evaluate the structural capital of the Russian innovation industrial cluster by addressing the following objectives:

1. To present the structure of the intellectual capital for the innovation industrial cluster and define its structural capital, which is part of the intellectual capital.
2. To analyse the internal and external environments of the innovation industrial cluster in Russia under study.
3. To propose a methodology for assessing the structural capital of the innovation industrial cluster.
4. To perform an assessment of structural capital of the innovation industrial cluster.

2. Literature review

The theory of cluster development continues to be a relevant subject of research by both domestic and international scientists (Saadatyar et al., 2020) due to the constant evolution of cluster associations (Ye et al., 2020). To a greater extent, the object of previous studies in the field has been industrial sectors of the economy (Stavroulakis et al., 2020), although research in health care (Yeoh, 2008), shipping (Stavroulakis et al., 2020), media industry (Komorowski, 2020), entertainment industry (Lehtonen et al., 2020), and other industries is relevant. The problems faced by cluster associations in their development are being clarified and classified (Saadatyar et al., 2020), with recent exploration of the influence of the geographical factor (Beck et al., 2019; Wang et al., 2018)we argue that in addition to facilitating organizational learning and specialization, an industry cluster related to tradition or to the practice of a craft influences audience expectations through the definition of the prototypical features that define an organizational form. Analyzing the population of northern Bavarian (Franconian and analysis of the interaction of cluster members (Fromhold-Eisebith et al., 2021; Wang et al., 2018). Particular attention has been paid to the innovative development of cluster associations (Sarvan et al., 2011; Žižka et al., 2018).

Recently, studies combining the application of intellectual capital theory and cluster development have begun to emerge, although their number remains insignificant. In 2013 (Jiang and Zhang, 2013), a study was conducted on the impact of intellectual capital on the production performance of technical innovation in the industrial cluster and revealed their insignificant influence (Zhilenkova et al., 2019).

The paper of Zhilenkova et al. shows the missed opportunities and offers guidelines for the production participants of the industry cluster, allowing for strengthening the position of cluster participants in the market through the management of intellectual capital. In 2020, the rapid industrial transformation (Alekseeva et al., 2020) appealed to the theory of intellectual capital to find an answer to the question of how to support regional innovation and entrepreneurship. Mikhaylov and Peker (2019) presented an assessment of the imbalance in the geographical distribution of leading universities, which are part of the cluster system during the transition to a knowledge economy, and an assessment of their integration into regional innovation systems. Chandrashekar (2019) examined the reasons for creating structural capital by cluster enterprises. Cho and Cho (2020) conducted a study on the exchange of elements of structural capital among cluster participants in the software industry. The study surveys entrepreneurs and employees of software start-ups and SMEs, and analyses the data collected using statistical analysis methods. In the present study, we extend the field by performing an assessment of structural capital in the software cluster.

3. Materials and methods

The study was performed on a sample of the innovation industrial cluster "Development of information technologies, radioelectronics, instrumentation, and means of communication and infotelecommunications of Saint Petersburg". The key specialisation of the cluster is information and communication technologies.

According to the analysis of information on cluster participants, most of them work under OKVED 62.0, "Development of computer software, consulting services in this field, and other related services". Therefore, the profitability indicators of Russian enterprises operating under this code were used as data for the type of activity.

Profitability indicators for the industry were obtained from the database created using the financial statements of Russian enterprises collected by the Federal Service for State Statistics and the Federal Tax Service, and posted on the website https://www.testfirm.ru. Information on the financial conditions of the enterprises-participants of the cluster, which was used to calculate performance indicators, was also obtained.

Calculations were made in February 2022; therefore, the analysis horizon was limited to 2020. The effectiveness of the cluster was assessed using profitability indicators according to the following formulas (1-3):

$$ROS_{OI} = \frac{OI}{Sales} \times 100\% \tag{1}$$

ROS_{OI} (Return on Sales) is the return on sales calculated from the operating income; OI is the operating income for the year; and *Sales* are the total revenue for the year.

$$ROS_{NI} = \frac{NI}{Sales} \times 100\% \tag{2}$$

ROS_{NI} is the net income margin, and NI is the total net income for the year.

$$ROA = \frac{NI}{(TA[b] + TA[e])/2} \times 100\% \tag{3}$$

ROA is the return on assets, and TA[b] and TA[e] are the value of assets (at the beginning [b] and the end [e] of the analysed period according to the balance sheet data).

The number of enterprises for which the values of profitability indicators by the type of activity were determined amounted to 23,935 in 2020. The list of analysed profitability indicators was limited to those available in public sources. The revenue and net profit of the cluster were defined as the sum of the revenues and net profits of all enterprises in the cluster, respectively.

The research methods used in this study are observation, surveys, questionnaires, analysis, synthesis, and mathematical modelling.

The structural capital of the innovation industrial cluster was assessed using the cost approach. Features of its implementation followed from addressing the study's Objective 1, "To present the structure of the intellectual capital in the innovation industrial cluster and define its structural capital, which is part of the intellectual capital", and Objective 2 "To analyse the internal and external environments of the innovation industrial cluster under study". The description of the proposed methodology is presented in Section 4.3 "Methodology for assessing structural capital of an innovation industrial cluster".

4. Results

4.1. Types of intellectual capital of the innovation industrial cluster

The innovation industrial cluster, as a type of cluster association, consists of a set of enterprises and organisations that participate directly or indirectly in the industrial sector of the economy and implement innovative activities. Human capital is an integral part of any enterprise or organisation and thus becomes a necessary part of the innovation industrial cluster. The innovativeness of the implemented activity determines the presence of structural capital, elements of which are registered and unregistered results of the intellectual activity. The peculiarity of cluster functioning in the market economy with a high level of competition determines the presence of relational capital consisting of trust, established connections, and created business reputation with internal and external stakeholders. Babkin et al. (2020) presented detailed composition and elements of the intellectual capital of the innovation industrial cluster. Thus, the intellectual capital of the innovation industrial cluster consists of human, structural, and relational capital.

As mentioned above, structural capital consists of registered and unregistered results of intellectual activity. In connection with the study of the industrial innovation cluster, such a cluster is expected to have the results of intellectual activity used to create innovations. The peculiarity of the operation of any economic entity leads to the emergence of the results of intellectual activity. They can include instructions, templates, forms, samples of documents, methodological guidelines, internal standards of activity, implementation of operations, and so on. Relying on the above list, we present the proposed structure of intellectual capital in the innovation industrial cluster (Figure 1).
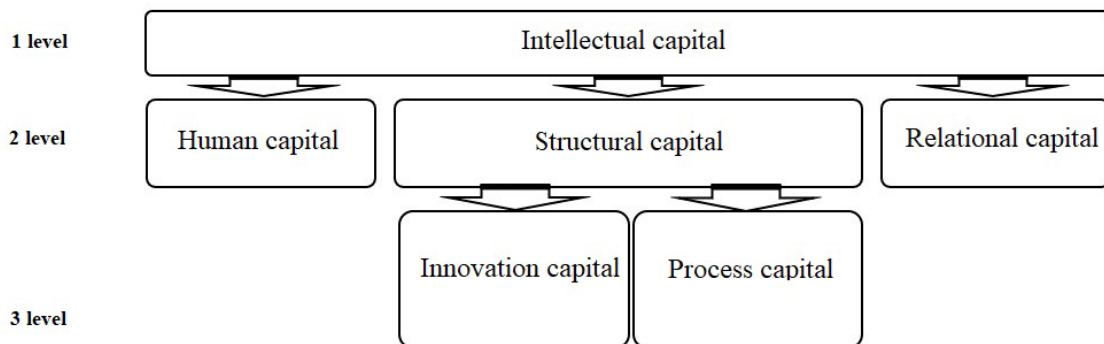

Figure 1. Structure of the intellectual capital in the innovation industrial cluster

The figure shows the types of capital that make up the three-level structure of intellectual capital in the innovation industrial cluster. One of the capitals of the second level is structural capital, which is further divided into innovation and process capital. The peculiarity of the elements of structural capital is their separability from both the individual who created them, and from the organisation-rights holder. This property distinguishes this type of capital from other types of capital that are part of the intellectual capital. Thus, we define structural capital as part of the intellectual capital of the innovation industrial cluster, which consists of the results of the intellectual activity, separable from individuals and legal entities, used in the innovation and process activity of the innovation industrial cluster.

4.2. Analysis of the internal and external environments of the cluster under study

In 2009, the government of the Russian Federation approved the rules for granting subsidies to Russian organisations for partial reimbursement of the costs of developing digital platforms and software products in order to create and enhance the production of high-tech industrial products. Support of developers of Russian software is carried out within the framework of the national programme "Digital Economy"[1]. The amount of funds allocated to support the national IT industry during 2020–2022 is 2 billion rubles annually. The share of necessary private financing is defined as not less than 50%. Subsidies can be provided to both small- and medium-sized enterprises. Apart from subsidising projects on the creation of software and digital platforms, other measures to support the IT industry are also provided, including reduction of tax deductions, demand stimulation, and expansion of the personnel base in the industry.

The state supports the development of the electronic and radioelectronic industry by granting subsidies for its development. According to the Ministry of Industry and Trade of the Russian Federation, the amount of spending by all regions of the Russian Federation in 2021 was 4.14 billion rubles, 16% of which were allocated to St. Petersburg. The dynamics of budget spending on St. Petersburg enterprises are given in Table 1.

Table 1. Expenditure of funds under the programme "Development of the electronic and radioelectronic industry for 2013-2025 in St. Petersburg", rub.

2016	2017	2018	2019	2020	2021
0	548 861 656	1 354 893 403	1 007 439 725	1 605 336 214	965 844 068

The innovation industrial cluster under study was created in 1999 by the initiative of the companies that later became their participants. The legal form of the association of the participants was a non-profit partnership. In 2012, the analysed cluster underwent significant transformations, and it was recognised by the state as a cluster supported by the government of St. Petersburg. The current name of the innovation and industrial cluster under consideration is "Development of information technologies, radioelectronics, instrumentation, means of communication".

According to the analysis of the information on cluster participants, most of them work under OKVED 62.0 "Development of computer software, consulting services in this field, and other related services".

As of March 1, 2022, 316 participating enterprises were registered in the cluster, and more than 22,000 people were employed. The cluster's annual revenue for 2021 was 42 billion rubles.

Figure 2 shows the dynamics of return on sales, net profit margin, and return on assets. The figure also shows the dynamics of the same indicators in the industry.

Figure 2. Return on sales, net profit margin, and return on assets by cluster and industry

[1]Available online at https://expert.minpromtorg.gov.ru/sphere/radio (accessed on 25.05.2022)

The return on sales by cluster for the period under consideration exceeded this indicator by type of activity. The only exception was 2018. Further dynamics of the compared indicators demonstrated a single case of such an excess, which allows us to conclude that the return on sales of the cluster as a whole was higher than the return on sales of the type of activity. The net profit margin of the cluster in each year of the period under consideration 2015–2020 exceeds the net profit margin by a type of activity, indicating a more efficient operation of the innovation industrial cluster.

The return on assets of the cluster for the period under consideration exceeded this indicator by type of activity. The only exception was 2019. The overall dynamics of the compared indicators demonstrated a single case of such an excess, allowing for the conclusion that the return on asset sales was higher than the return on sales by a type of activity.

Generally, the analysis of the presented indicators showed more effective work of the innovation industrial cluster in comparison with individual enterprises operating in the same type of activity, which indicates the presence of intellectual capital in the cluster.

4.3. Methodology for assessing the structural capital of the innovation industrial cluster

As discussed above, structural capital consists of innovation and process capital, which determines the need to summarise innovation and process capital to determine the amount of the structural capital in our target cluster (formula 4):

$$C_{SC} = C_{IC} + C_{PC} \qquad (4)$$

Where C_{SC} is the cost of the structural capital;

C_{IC} is the cost of the innovation capital;

C_{PC} is the cost of the process capital.

To determine the cost of the structural capital, the cost approach is used, the essence of which is to determine the cost by summing up the costs of creation. The costs of creation will include expenses on payroll with social deductions, materials, and expenses on operation and depreciation of equipment used to conduct the research and development work required to create elements of the structural capital. Here, we must consider expenses for business trips, consultations, and purchase of necessary property rights if they took place during the creation of elements of the structural capital. If an element of the structural capital was acquired, the costs of its creation would be the costs of acquisition.

Considering that when creating elements of the structural capital, the future right holder bears risks and takes money out of circulation for the creation of the structural capital, which could have been used in another way, the amount of creation costs should be increased by the value of the money used. We propose using the return on assets of the innovation industrial cluster determined earlier as the value of money used to create elements of the structural capital.

The evaluation of intellectual property, performed on the basis of the cost approach, has its own peculiarities. It is necessary to take into consideration not only the expenses made but also their effectiveness. In this case, we propose doing so based on the assessment of the influence of an element of the structural capital on the activities of participating enterprises that use it. It is also necessary to allow for the fact that this study considers the assessment of the structural capital of a cluster association. Therefore, we propose considering the scope of their use to allow for the effectiveness of the use of elements of the structural capital.

We also propose assessing the influence of an element and the scope of its use with an expert survey. The experts are employees of the participating enterprises. There is no need to involve external parties, as they do not have the necessary information.

To assess the influence of the structural capital element on the activity of participating enterprises,

experts are asked the following question: "To what extent does this element influence such measures as time, quality, money, prospects of development of the innovation industrial cluster?" An expert writes down the answer in numerical form, guided by the scale of responses given in Table 2.

Table 2. Scale of responses by strength of influence

Score	Response
0	Has no influence
1	Has little influence
2	Has a medium influence
3	Has a strong influence

To assess the scope of the use for structural capital elements, the experts are asked to answer the following question: "How many enterprises participating in the innovation industrial cluster use this element in their activity?". The response options and their scoring are given in Table 3.

Table 3. Scale of responses by influence size

Score	Response
0	None
1	Less than 25% of enterprises in the cluster
2	25%-50% of enterprises in the cluster
3	More than 50% of enterprises in the cluster
4	More than 75% of enterprises in the cluster

Taking into consideration the nature of the questions and possible responses, we recommend involving leading specialists and top management in the expert survey. The results of the survey are processed to determine the integrated assessment of the influence of the intellectual capital element on the activity of the innovation industrial cluster, calculated by the following formula (5):

$$EIC = EPI * ESI \tag{5}$$

EIC is the expert assessment of the importance of contributions to the cluster;

EPI is the expert assessment of the power of influence;

ESI is the expert assessment of the scope of influence.

The proposed integral coefficient also takes into consideration the depreciation of the structural capital element; thus, there is no need to further include it in the assessment.

Based on the above, the formula for calculating the cost of structural capital is as follows (formula 6):

$$Csc = \sum Cs*(1+R)*EIC + \sum Ca*EIC \tag{6}$$

Cs is the cost of creating an element of the structural capital, currency units;

Ca is the cost of acquiring an element of the structural capital, currency units;

R is return on assets, %;

EIC is the expert assessment of the importance of contributions to the cluster.

4.4. Assessment of the structural capital of the innovation industrial cluster

The data for calculating the costs of creation were obtained through a survey of the enterprises participating in the cluster under study. The analysis of the results of the survey revealed that for the cluster under study, most of the creation costs are related to labour costs, which determines the structure of the costs presented below.

Table 4 presents the results of the assessment of the structural capital of the innovation industrial cluster under study, obtained using the proposed methodology.

Table 4. Results of calculating the value of the structural capital of the innovation industrial cluster

Indicator	Value
Creation time, man-hours	3,444 809
Weighted average level of wages, rubles/person/month	44,980
Other expenses, % of payroll	10%
Return on assets	14%
Expert assessment of the importance of contributions to the cluster	0.84
Process capital, million rubles	971
Creation time, man-hours	19,684,610
Weighted average level of wages, rubles/person/month	44,980
Other expenses, % of payroll	10%
Return on assets	14%
Expert assessment of the importance of contributions to the cluster	0.93
Innovation capital, million rubles	6,144
Structural capital, million rubles	7,115

Based on the calculations, we determined that the value of the structural capital in the innovation industrial cluster under study amounted to 7,115 million rubles.

5. Discussion

As stated earlier, cluster development in Russia does not meet the expected level, which makes the research on increasing the effectiveness of cluster operation relevant. In the present paper, emphasis is placed on the use of intangible components of the activity in the innovation industrial cluster. We proposed a methodology, and an assessment of the structural capital of the cluster was carried out, the results of which will allow for the evaluation of the current state of the use of intangible assets of the cluster, as well as identifying the prospects for development of the structural capital. Although previously published works investigated the reasons for creating structural capital by cluster enterprises (AlQershi et al., 2021; Chandrashekar and M.H., 2019) and identified the facts of the exchange of structural capital elements between cluster participants in the field of software (Andreeva et al., 2021; Cho and Cho, 2020), the presented work investigated the results of such exchange and determined the value of the structural capital in the innovation industrial cluster.

To substantiate the composition and elucidate the essence of the structural capital of the innovation industrial cluster, this paper presents the structure of the intellectual capital of the innovation industrial cluster, consisting of three levels and taking into consideration the innovative nature of operation in the cluster under study. This structure enables the proposal of a methodology for an accurate assessment of the intellectual capital of the innovation industrial cluster without mixing with its other types of capital, which is a unique feature of the work presented. The paper also provides a definition of structural capital for the innovation industrial cluster, which allows clear identification of the components of the structural capital in the innovation industrial cluster and ensures the absence of duplication of its elements during assessment.

The analysis of the factors of the external environment of the innovation industrial cluster allowed identifying the prospects created in the country for the growth of the structural capital in the innovation industrial cluster, and, accordingly, determining the relevance of the study of structural capital management to achieve competitive advantages. The analysis of the factors of the internal environment of the innovation industrial cluster indicated the presence of intellectual capital, which makes its assessment relevant to the current framework. The results of the analysis of the internal environment were used to assess the structural capital of the innovation industrial cluster.

The proposed methodology for assessing the structural capital of the innovation industrial cluster allows for exchanging elements of the structural capital between the cluster participants in the software industry identified earlier by Cho and Cho (2020) and allows for the effects of exchange in the assessment, which distinguishes the proposed methodology for assessing the structural capital of the innovation industrial cluster from assessing the structural capital of individual enterprises.

The results of calculating the value of the structural capital in the innovation industrial cluster made it possible to determine its value in the amount of 7,115 million rubles, while the innovation capital accounts for 86% of this value; the remaining part of 14% relates to the process capital of the cluster. This structure confirms the innovative nature of the cluster under study. The work carried out with the enterprises participating in the cluster revealed that the cluster had great potential to increase its structural capital through documenting and registering rights to the results of the intellectual activity. Implementation of the recommendations on registration of the results of the intellectual activity will allow the cluster to reduce the risks of dependence on personnel (Pavlov et al., 2022), as well as increase income through the transfer of proprietary rights to the results of intellectual activity.

Future research should develop theoretical, methodological, and practical provisions for assessing the capital of the innovation industrial cluster. The study presented materials that can be used to guide management decisions in innovation clusters and enterprises when evaluating intellectual property.

6. Conclusion

This paper presents the results of the study and the assessment of the structural capital of the innovation industrial cluster in Russia. The following summarises the main findings:

1. An analysis of internal and external environments of the innovation industrial cluster under study revealed that Russia allocates substantial funds to support the IT industry, as well as the electronic and radio-electronic industries. The comparison of indicators of the financial and economic activity in the cluster with similar indicators by type of activity revealed a higher effectiveness of the cluster, which indicates the presence of intellectual capital in the innovation industrial cluster under study.

2. A methodology was proposed for assessing the structural capital of the innovation industrial cluster, which is based on the application of the cost approach to assessment and with allowance for the available in the studied cluster documented and undocumented results of the intellectual activity.

3. Structural capital of the innovation industrial cluster assessed by the proposed methodology was valuated as 7, 15 million rubles.

In collaboration with the enterprises participating in the cluster, this study showed that the cluster had great potential to increase its structural capital by documenting and registering the rights to the results of intellectual activity. The implementation of recommendations on registration of the results of intellectual activities will allow the cluster to reduce the risks of dependence on personnel, as well as to increase income through the transfer of proprietary rights to the results of intellectual activity. The presented work makes it possible to assess the growth reserves available to the cluster on the use of its intellectual capabilities. Other types of the intellectual capital of the innovation industrial cluster are subject to further research.

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