DOCTORAL THESIS

Cluster Industrial Policy and Tools in Transition Economy: The Case of Russia

Tatiana Kudriavtseva

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Declaration:
Hereby I declare that this doctoral thesis, my original investigation and achievement, submitted for the doctoral degree at Tallinn University of Technology has not been submitted for doctoral or equivalent academic degree.

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Contents

List of Publications

The following is a list of author's publications, on the basis of which the thesis has been prepared.

I Tatiana Kudryavtseva, Eunice Omolola Olaniyi (2020). Identification and analysis of the cluster structure of a territory and its impact on regional development: an example of Russia. Journal of Advanced Research in Law and Economics, Volume X, Summer, 4(42)
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II Tatiana Kudryavtseva, Angi Skhvediani, Mohammed Ali Berawi (2020). Modelling cluster development using programming methods: case of Russian arctic regions. Entrepreneurship and sustainability issues, 2020 Volume 8 Number 1 (September), ISSN 2345-0282
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T. Kudryavtseva, D. Rodionov & A. Skhvediani (2018). An empirical study of information technology clusters and regional economic growth in Russia. In SHS Web of Conferences (vol. 44). EDP Sciences. DOI: https://doi.org/10.1051/shsconf/20184400050
(ETIS Classification 3.2)

III Kudryavtseva, T. J. (2016). Research of cluster structure in regions of Russia (Case Study: St. Petersburg). *Business challenges in the changing economic landscape* (vol. 1). Springer, 437–448.
(ETIS Classification 3.1)

IV Kudryavtseva, T. J. (2015) Methodical bases of identification and ranking of developed cluster groups of regional economy (case study: St. Petersburg). Proceedings of the 25th International Business Information Management Association Conference - Innovation Vision 2020: From Regional Development Sustainability to Global Economic Growth, IBIMA, 1147–1158.
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Author's Contribution to the Publications

Contributions to the papers in this thesis are as follows:

I The author was the lead in the co-authored study. The author systemised methods for identification of the cluster territory structure and approaches for estimation of its' influence on economic growth. The author applied identified approaches to the analysis of the 37 clusters in 83 regions of Russia for 2011–2015. The author contributed to the analysis of the obtained data and concluded that regional specialisation results in positive effects for Russian territory.

II This work is a co-authored research paper. The author systemised existing approaches to the assessment of cluster territory structure and developed the "Clusters of Russia's regions" database for its' automated analysis. The author participated in the description of the obtained results for Arctic regions of Russia for the 2009–2018 period and a discussion of the possible implications.

III This work is a co-authored research paper, which is dedicated to the research of IT cluster localisation in Russian territory for 2008–2016 period. The author has proposed a methodology and instruments for assessment of cluster territory structure. The author applied this methodology to the IT cluster. Author has participated in the description of the obtained results and concluded that strengthening the regional specialisation of the IT cluster in Russian territory results in positive externalities for the region.

IV The work was a single-authored paper, which is a continuation of single-authored work *Methodical bases of identification and ranking of developed cluster groups of regional economy (Case study: St. Petersburg).* In this paper, the author has explored the methodology of the European cluster observatory and applied it to the micro- and macro-levels of St. Petersburg's territory cluster structure for the 2008–2012 period.

V The work was a single-authored paper. In this paper, the author systemises approaches of the European, Russian, and U.S. cluster observatories to analyse the cluster structure of St. Petersburg for 2012.

Other Articles and Conference Proceedings of Doctoral Studies

Scopus and/or Web of Science publications:

I Kudryavtseva, T. J. Analysis of the State and Dynamics of Chemical Industry in Russia / T. J. Kudryavtseva, I. V. Kovalenko // Financial Environment and Business Development. – Springer, Cham, 2017. – c. 413–422.

II Kudryavtseva, T. Special economic zones as an instrument of industrial policy pharmaceutical clusters in Russia / T. Kudryavtseva, D. Rodionov, V. Kravchenko, V. Maryta // Proceedings of the 28th International Business Information Management Association Conference - Vision 2020: Innovation Management, Development Sustainability, and Competitive Economic Growth. – International Business Information Management Association, IBIMA, 2016. - c. 1008–1018.

Publications in Russian leading journals (in Russian):

III Kudryavtseva, T. Yu. Categorization of cluster promotion institutional forms / T. Yu. Kudryavtseva // Russian economic online journal. – 2018. – № 4. - p. 60–60.

IV Kudryavtseva, T. Yu. Mechanism and principles of cluster industrial policy formation / T. Yu. Kudryavtseva, D.G. Rodionov // Innovations. – 2018. - № 10.

V Kudryavtseva, T. Yu. Innovative instrumentation cluster in St. Petersburg: myth or reality? / T. Yu. Kudryavtseva // Innovations. – 2016. – №. 12 (218). – p. 95–103.

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VII Kudryavtseva, T. Yu. Analysis of dynamics of an economic condition of branches developed cluster groups of St. Petersburg / T. Yu Kudryavtseva, N. P. Zhabin // Journal of Economy and entrepreneurship. - № 11-4 (52-4). – p. 351–354.

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X Kudryavtseva, T. Yu. Identification of Industrial Clusters / S. S. Gutman, T. Yu. Kudryavtseva // Economics and Management. – 2012. – №. 10(84). – p. 62–64.

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XII Kudryavtseva, T. Yu. Problems and directions of the regional industrial policy formation (for example, St. Petersburg) / A.V. Babkin, A.V. Bakhmutskaya, T. Yu. Kudryavtseva // News of St. Petersburg State University of Economics. – 2011. – №. 4. – p. 27–33.

Articles in professional journals and scientific collections (in Russian):

XIII Kudryavtseva, T. Yu. Problems of implementing cluster policy in Russia / E.I. Nataeva, T. Yu. Kudryavtseva//Week of Science SPbPU: materials of the scientific-practical conference. Institute of Engineering and Economic SPbPU. – 2015. – p. 34–36.

XIV Kudryavtseva, T. Yu Assessment of the effectiveness of the state cluster policy of St. Petersburg / T.Yu. Kudryavtseva, S.A. Utkina // Innovative economy and industrial policy of the region (ECOPROM-2014). – 2 SPb: publishing office of the St. Petersburg State Polytechnic University, 2014. – p. 216–225.

XV Kudryavtseva, T. Yu. (2014) The structure of the industrial cluster of instrumentation in St. Petersburg / T.Yu. Kudryavtseva, S.A. Kurzaeva, S.A. Utkina // Management of innovative activities of economic systems (INPROM-2014): proceedings of an international scientific and practical conference. Ed. A.V. Babkin. – SPb: publishing office of the St. Petersburg State Polytechnic University 2014. – p. 334–339.

XVI Kudryavtseva, T. Yu The cluster as an innovation-oriented form of spatial concentration of enterprises: a synthesis of foreign experience / V.V. Maryina, T.Yu. Kudryavtseva // Russia in the global world. – SPb: publishing office of the St. Petersburg State Polytechnic University, 2013. – №3 (26). – p. 55–69.

Introduction

Background and context

Placing economic agents in close geographical proximity to each other and establishing mutual relations for better performance in terms of a certain economic activity are factors that trace back to the advent of cities in the Ancient World. Clusters, bound by close ties, are still an important economic phenomenon in the 21st century, responsible for raising the most successful market players in a wide range of global sectors (Chen & Liu, 2021; Stavroulakis et al., 2021). Active participation in industrial clusters in the second half of the 20th century provided one of the best opportunities for small and medium businesses to survive and stay competitive at the regional, international, and even global levels (Porter, 1998a; Ranman & Kabir, 2021; Turkina & Van Assche, 2018). However, former market leaders can lose their positions due to the problems at the federal, state, and cluster levels (Porter et al., 2011), sanctions imposed against different sectors of the economy, which are followed by protecrionism policy towards domestic companies (Zemtsov et al., 2017), technological disruptions (Østergaard & Park, 2015), competition from young, flexible, and innovative companies and start-ups (Ferràs-Hernández et al., 2017). Some of these large companies were also capable of using the huge potential and opportunities provided by industrial clusters. As a rule, they did this by placing key operations of the company in industrial clusters meticulously selected around the entire globe or using these industrial clusters as major innovators in the value chain (Chandrashekar & Hillemane, 2018).

However, the cluster phenomenon existed in the command economy of the USSR, where industrial policy was based on the development of territorial production complexes. The idea behind territorial production complexes was vertical and horizontal integration of enterprises to receive the economy from localisation. The main difference between territorial production complexes and clusters is the absence of competition between enterprises. Therefore, production chains in territorial production complexes were established and planned by the government (Pilipenko, 2004). During the transition from command to market economy, these linkages were disrupted, and production chains partly or fully were replaced by imports of final and intermediate products. Further, resource richness and oil dependence of Russia has boosted the decline of the manufacturing industries and territorial production complexes in transition stages from command to market economy.

Fromhold-Eisebith and Eisebith (2008) consider cluster policy as public and private measures that magnify agglomeration effects. However, in Russia, cluster policy is often implemented using the principle “cluster must be here” and often results in “state failures”, whose nature is close to “market failures”, since there is an information asymmetry in the system of public administration (Babkin et al., 2011).

To make industrial policy effective, it is necessary to establish and implement scientifically proven priorities and the contents of industrial development programmes in the long run, taking into account the specifics of the transitional economies. These specifics arise from lower stages of economic development of the country, lower levels of integration in global value chains, political factors, disruption of the established production chains, resource dependence, and instability of the economy. If these specifics are not taken into account, then cluster-based economic policy will not be effective, since it mainly arises from the experience of the developed economy.

For example, a study (Islankina & Thurner, 2018) on 25 pilot cluster initiatives in Russia that received financial support under the national programme and concluded that there was no relationship between the invested capital and the labour productivity of employees of enterprises that were part of cluster projects.

To address this situation, there is a need for well-developed theoretical and methodological approaches to establishing industrial policy with due consideration of the factors of the institutional environment of the transitional economy.

Problem statement and research gap

Cluster industrial policy is the subject of scientific discussions (Lee et al., 2017). Many authors consider clusters in terms of their classification, identification (Kopczewska et al., 2017), and defining the factors that affect them positively (Lis et al., 2020; Slaper et al., 2018). Some others proceed from the theses of the official cluster policy and study the development of the clusters set up on the basis of regulations and decrees of the Government (Zemtsov et al., 2017). This limits the possibility of considering clusters that are set up due to private initiatives. However, an important question arises – whether the decision-makers have enough methods and tools to identify clusters and evaluate the effects of cluster industrial policy, taking into account specifics of transition economy.

In particular, institutional theory can be used to complement cluster-based economic policies and tools in the case of the institutional structure of the Russian transition economy. Therefore, this research is based on the idea that a successful cluster policy should be based on the current economy profile of the country, which reflects its specific features. For example, in the Russian case, it is necessary to take into account its resource richness and transition from command to market economy, in particular from territorial production complexes with fixed links between enterprises to clusters, which should be built in global value chains and compete with each other. Thus, it is necessary to identify the statistical parameters that reveal the concentrated types of activity in a certain territory, defining the connections between the types of activity and their clustering, as well as automating their calculations, mapping them on a regional level, and measuring the externalities that occur due to the clusters localised in the territory.

Some authors have studied different types of sectoral clusters localised in the Russian regions as well as the microstructure of individual clusters. For example, authors from the Russian cluster observatory mainly focus on the analysis of official clusters developed by the government. The literature does not pay enough attention to analysing the cluster structure of the regions of Russia or evaluating their impact on economic growth. This problem is especially crucial for the transitional type of the Russian economy. Therefore, to tackle this gap, the author developed a complex methodology for analysis of the territory cluster structure at micro-, meso-, and macro-levels and its' application to the case of Russian regions.

Aim and scope of work

The research study is aimed at developing theoretical and methodological guidelines for forming and implementing cluster industrial policy at the micro- and macro-levels with regard to institutional, regional, and industry-specific factors in Russia.

The following research questions are addressed in this study:

RQ1: What methods and tools can be used to identify and analyse the cluster structure of the Russian transition economy?

RQ2: What is the effect of industrial clusters on the economy of Russian regions?

RQ3: What is the cluster industrial structure of Russia and St. Petersburg?

RQ4: What is the relationship between the objectives, methods, and elements of cluster policy in a transition economy?

The object of the research is industrial clusters at the macro- and micro-levels. **The subject of the research** is the theoretical and methodological grounds for forming and implementing cluster industrial policy in a transition economy.

Figure 1 portrays the overall logic of the research and illustrates the overall structure of the cover paper.

The theoretical background relates to the first chapter of the cover paper. I discuss the existing background of cluster research and identify the research gap.

The research design of cluster structure identification and analysis is presented in Chapter 2 of the cover paper. Chapter 2 provides answers to RQ1 and presents the methodological background of the research.

Chapter 3 presents the results of cluster structure identification and analysis in Russia and the theoretical contributions of this research.

Chapter 3.1 presents the results of Russia's regional cluster structure study for the period of 2008–2016 and provides a partial answer to RQ3; the industrial clusters, determining the positive externalities for the economy of Russia's regions, were identified for the period of 2008–2016, and the answer to RQ2 was presented. In more detail, the results of the research are presented in articles A1, A2, and A3 (Kudryavtseva & Olaniyi, 2019; Kudryavtseva et al., 2020; Rodionov et al., 2018). Chapter 3.2 presents a detailed analysis of one of the Russian regions – St. Petersburg in order to complete answer to RQ3. I evaluated the dynamics of the industry-specific cluster structure of St. Petersburg for the period 2008–2016, identified the factors limiting the development of industrial clusters, defined the institutional forms for promoting St. Petersburg's clusters, and substantiated the action items of St. Petersburg's cluster industrial policy. This section presents how instruments of cluster industrial policy can be applied at example of the concrete regions. In more detail, these results are presented in articles A5 and A4 (Kudryavtseva, 2015; Kudryavtseva, 2016).

The Discussion section provides answers to RQ4 and contributes to the theory by presenting the mechanism of cluster industrial policy in the transition economy.

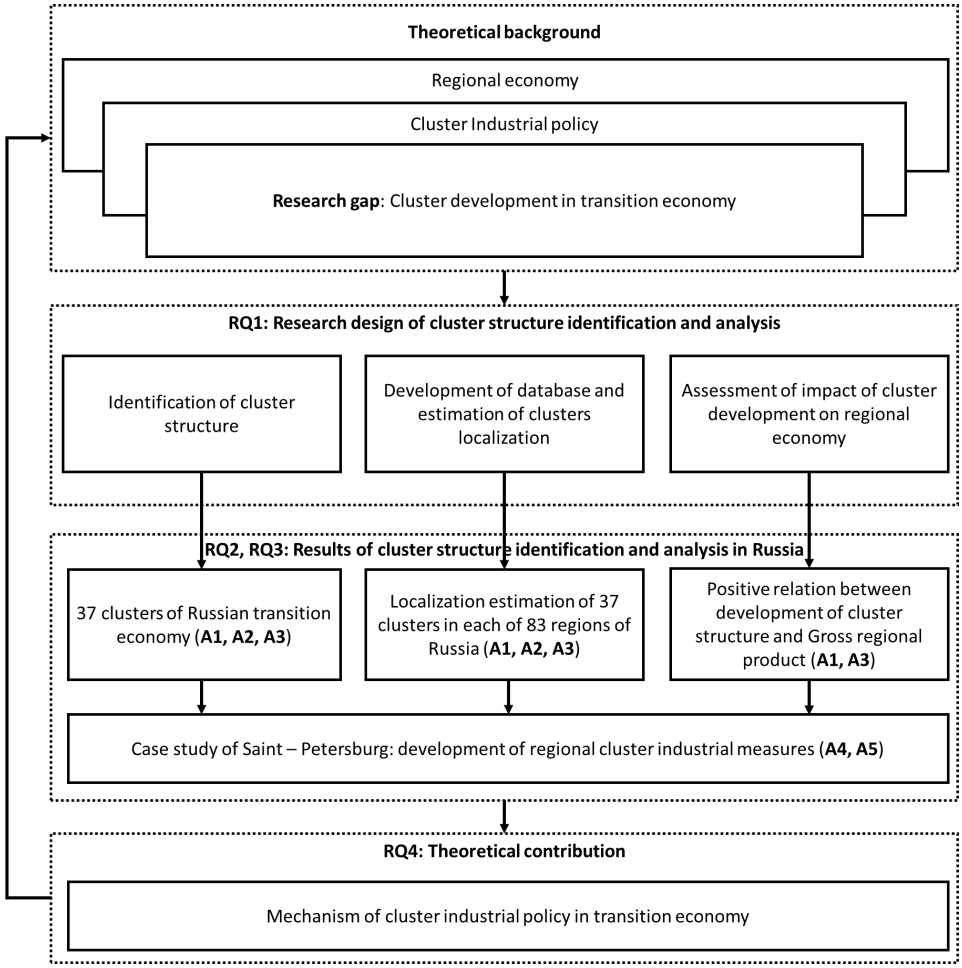

Figure 1. – Flowchart
Source: composed by the author

Abbreviations

GRP	Gross Regional Product
IT	Informational technology
LQ	Locational quotient
MAR	Marshall – Arrow – Romer
NACE	Nomenclature statistique des Activités économiques dans la Communauté Européenne
OKVED	Russian Classification of Economic Activities
RIiFA	Investment (rubles, at constant prices of year 2000) in fixed capital
SIC	Standard Industrial Classification
TPC	Territorial & Production complex

1 Literature review

In Section 1, I provide the theoretical and methodological background the research. First, I discuss the idea of the industrial cluster and its place in the framework of cluster industrial policy. Next, I briefly discuss the different externalities generated by clusters as part of the regional economy. After that, I discuss cluster policy from the position of the institutional economy. Next, I reveal the development of clusters in conditions of transition economy. At the end, I set ground for research of clusters in transition economy at example of Russia. Therefore, this literature review sets the foundation for the development of the methodology for forming and implementing cluster industrial policy at the micro- and macro-levels with regard to institutional, regional, and industry-specific factors in the transition economy.

1.1 Notions, classification criteria, and structure of an industrial cluster

To establish the background of the research, it is necessary to define the main concepts and terms that I use.

This research is based on combining the following principles of cluster theory: determining the statistical parameters, reflecting the types of activity concentrated in a certain territory, identifying the connections between the types of activity and their joining in clusters, evaluating the impact that clusters have on the development of the territory, automating cluster identification calculations, and cluster mapping. Let us consider these principles and their interconnections.

The principles of cluster theory were formulated by Haig, who analysed the structure of urban economics. Based on the analysed values of the localisation coefficient (relative concentration) of certain types of activity, he identified the basic part contributing to the economy of a region due to export and a non-basic part of the region's economy, supporting the basic one (Rodwin, 2017). One of the constraints emerging when localisation coefficients are used for cluster identification that should be mentioned is cluster sensitivity to the administrative borders of the territories. This is because some clusters can have a clearly marked interregional rather than subnational nature, which cannot be registered and considered using localisation coefficients. This idea was then explored in the works by M. Porter, who used cost tables–output to determine the interrelated types of activity, identifying economic clusters (Delgado et al., 2015; Porter, 1998b; Xiao & Wang, 2019), and cluster mapping.

I use definition of the cluster, developed by M. Porter: "a geographic concentrations of interconnected companies, specialised suppliers, service providers, firms in related industries, and associated institutions (e.g., universities, standards agencies, trade associations) in a particular field that compete but also cooperate" (Porter, 1990, 2000). Later, this definition of the cluster was extended by various researchers and more commonly became the term industrial cluster (Cooper & Folta, 2017; Delgado et al., 2014; Ketels & Protsiv, 2014). For this term, I use the definition developed by Bortoluzzi et al. (2015): cluster is "a geographic concentration of interconnected firms, suppliers, and institutions in a particular field. It has the potential to affect competition by increasing the productivity of the companies in the clusters, driving innovation, and stimulating new businesses in the specific field". Therefore, a considerable part of the social community and economic entities work together inside the industrial cluster, carrying out economically related activities, jointly developing and improving products, technologies, and organisational knowledge to create the best products and services on

the market (Franco & Esteves, 2020; Halse, 2020). There are four main distinctions between industrial clusters and other agglomeration models.

First, industrial clusters imply intensive interactions that transfer knowledge between firms, and these interactions often become tighter than those inside a firm (Bachtiar et al., 2021; Brenner et al., 2011; Gress, 2015). To cooperate and compete simultaneously in a geographic zone calls for a well-developed social structure, which suggests and facilitates integration of knowledge and communication exchange, and contributes to joint identity among economic agents (Prause, 2014).

Second, industrial clusters include a totality of economic agents – both legal and natural – having special skills or knowledge related to the economic activity they carry out. These economic agents form institutions such as universities, research centres, industrial associations, and technological institutes, which stimulate mutual economic cooperation and the spread of technological knowledge between the members of an industrial cluster. One of the possible structures of an industrial cluster, which reflects the interrelation of its main elements, can be broken down into a core, production infrastructure, and business infrastructure. The core of a cluster is the totality of enterprises with the same or similar sector profiles.

Third, a cluster is a specific form of spatial concentration of enterprises whose joint activity entails specific agglomeration externalities, that is, external effects. To ensure this interaction, there should be the so-called "social glue" (Morosini, 2002, 2004), binding a cluster and helping the social consolidation of various structural participants and integration of main knowledge, which occurs through cultural, organisational, and functional boundaries.

Fourth, this definition of an industrial cluster highlights that the final goal of industrial clusters is to create high-quality products and services that represent value for customers on the market. To reach this goal, industrial clusters should have the following characteristics: leadership, structural elements, communication, knowledge transfer, and professional rotations (Porter & Kramer, 2019; Xiangfeng, 2007).

Morosini (2002, 2004) suggested and substantiated the classification criteria of clusters, developing the theory of cluster classification and determining the development dynamics of a cluster, such as an institutional structure, the results of joint activity, economic connections, an interaction of the elements of a cluster, as well as the classification criteria of the competitive factors of clusters: external, internal, and social ones.

The main competitive factors of firms united in a cluster are external, internal, and social factors. The externalities of competition are legal regulation, consumers, raw material, technology, and knowledge markets; the internalities are the resources, processes, and competences of firms; and the social factors are acquisition, creation, and sharing knowledge, as well as behavioural and cultural standards. The degree of knowledge integration and the scope of competition are the major factors that precondition the economic performance of industrial clusters (Ketels & Protsiv, 2020). Firms in industrial clusters that demonstrate a high degree of knowledge integration and competing on the global level introduce more innovations are more inclined to growth, adapt faster to the changing environment, and have more stable economic performance in comparison with firms in less integrated clusters, where competition is strictly limited by local territorial boundaries (Dyba et al., 2020; Maghssudipour et al., 2020). Based on the scientific literature review, it can be concluded that the higher the degree of knowledge integration between the participating firms and the higher the level of global competition of the participating firms, the higher the competition of clusters.

1.2 Clusters as part of the regional economy

Thus, foreign studies broadly cover the results of the identified and analysed status of the cluster systems in individual countries and regions. For example, Looijen and Heijman (2013) identified and analysed agricultural clusters in the European Union. Lindquist (2009) analysed the concentration and urbanisation of industries in Sweden and built cluster maps for Sweden. Delgado et al. (2014) designed an algorithm for cluster identification and studied agglomeration effects of the US regional clusters (Delgado et al., 2015).

Studying MAR, Jacobs, and Porter's agglomeration externalities by evaluating their impact on regional and sectoral indicators is a popular area of research in cluster economics (Bavina, 2016; Beaudry & Schiffauerova, 2009; Zemtsov et al., 2017). The MAR concept (Marshall–Arrow–Romer, MAR) of externalities was formalized by (Shleifer, Glaeser, Kallal, Scheinkman, & Shleifer, 1992). The common part of MAR, Jacobs, and Porter's models is the consideration of geographical effects from the spatial distribution of firms in a region (agglomeration pattern) (Kopczewska et al., 2017). The concepts of urbanisation and localisation can be used in a broad sense as agglomeration components, and, consequently, as elements of the economies of agglomeration. The economies of agglomeration or agglomeration effects are economic benefits obtained as a result of industries concentrated in one territory relatively close to each other (Macheras & Stanley, 2017; Pinto & Sablik, 2016).

Economies of agglomeration can be divided into two types: economies of localisation or localisation effects and urbanisation economies or urbanisation effects. Urbanisation effects are produced due to many industries concentrated in one territory. Consequently, the diversified economic system allows enterprises to obtain benefits from various types of the economic activity undertaken in this territory (Dicken & Lloyd, 1990; Macheras & Stanley, 2017). Thus, Jacobs emphasizes the importance of competition and diversification, downplaying the role of specialisation (De Groot et al., 2009).

The economy of localisation arises as a result of the concentration in one territory of firms working in the same industry or industries related to it. As a result, firms can join in clusters and obtain benefits, for instance, from sharing the infrastructure and creating enough demand for materials and components (Macheras & Stanley, 2017; Malmberg & Maskell, 2002). The study by Rodriguez-Clare statistically and dynamically models the efficiency assessment of state industrial policy, namely, cluster subsidising, in terms of achieving Marshall's externalities (Rodríguez-Pose & Comptour, 2012; Rodríguez-Pose & Crescenzi, 2008). As a result, the author assessed the subsidising efficiency of the sectors highly prone to clustering in the context of growing wealth. The modelling also supported the conclusion that subsidising a sector makes sense only in cases where the protected sector has Marshall's externalities, and the country has a natural comparative advantage in this sector.

Thus, the concept of the economy of localisation is, in fact, a synonym for MAR externalities, while urbanisation economies are a synonym for Jacobs externalities. Porter's externalities have features and characteristics common to both models.

1.3 Cluster as the object of cluster industrial policy

There can be mainly two types of 'cluster policy': one supports the growth of existing or embryonic regional clusters, and the other allows the knowledge of how industrial development occurs in (successful or unsuccessful) regional clusters inform policy making in general (European Comission, 2002). One of the main tools of cluster policy is

cluster initiatives, which are defined as organised efforts to increase the growth and competitiveness of clusters within the region, involving cluster firms, government and/or the research community (Chen et al., 2020; Sölvell et al., 2003).

The concept of a cluster has become a popular principle in the industrial policy of developed countries, stimulating industrial competitiveness and innovativeness based on sectoral specialisation and cooperation. Despite a broad public interest in the applicability of the concept of the promotion of industrial clusters, studies have only partially covered this subject. The discussions have only about what assets and dynamics underlie successful clusters (Lee et al., 2017; Van Den Berg & Braun, 2017) and how the "map of examples" can be empirically identified, categorised, or produced (Looijen & Heijman, 2013; Sternberg & Litzenberger, 2004; Zemtsov et al., 2017). Scholars are increasingly studying how the development of clusters can be supported internationally and whether that should be done in the first place (Delgado et al., 2014; Gibson, 2015; Ketels & Memedovic, 2008). However, three major drawbacks are common to these discussions.

First, the focus has been on describing, comparing, and categorising official cluster policy (Boekholt & Thuriaux, 1999; Schönfeld & Jouaillec, 2008), which makes most researchers leave out the fact that cluster effects also rise from private initiatives, and often have nothing to do with industrial policy. This limits the number of clusters considered and limits the discussion about whether government bodies are a suitable option for supporting the development of clusters (Felzensztein et al., 2018; Lin et al., 2012; Prokhorova et al., 2018).

Second, how institutional forms of cluster promotion, that is, the ways of organising, managing, and relative norms and clusters of interaction, affect the outcome has not been properly investigated, although there is the recognition that institutions are important assets of clusters and provide innovative support at the regional level (Kiese, 2019; Lundequist & Power, 2002; Yoon, 2017).

Third, researchers rarely consider an important objective of evaluating the effects of cluster support as an ability to measure the performance of clusters, which is essential for justifying the choice of strategy and achieving the best results under the existing conditions, because this entails methodological complications (Kopczewska, 2018; Lindqvist, 2009; Russu, 2016). Thus, the theory of cluster industrial policy is a controversial area, which "astonishingly lacks a consensus about how clusters emerge and to what extent their appearance can be caused by target planning or political intervention".

The study by Maskell and Lorenzen (2004b) proves a hypothesis that the spatial localisation of industrial clusters is the essence of the market organised in an especially reasonable way. To maximise the advantages of market relations and simultaneously keep transaction costs at a low level, firms take part in setting up institutions – they organise the market. (Maskell & Lorenzen, 2004a, 2004b). Consequently, a cluster is one of such specific market organisations structured by territorial lines since it can be used to create a set of institutions beneficial for certain types of economic activities, particularly for industries that have a high degree of uncertainty and well-developed social institutions. Common institutions in this form of market help the participants of a cluster end up with an environment that reduces obstacles for acquiring and using knowledge created or applied locally (Maskell & Lorenzen, 2004a, 2004b).

Therefore, in my opinion, the existing scientific approaches to this subject have some drawbacks: the fact that cluster effects arise, mainly, from private initiatives and often have nothing to do with "cluster promotion" policy has not been taken into account.

Further, how institutional cluster promotion forms affect the result needs to be fully studied, and evaluating the effects from cluster support has not been practically considered.

Therefore, it is essential to understand that the main risk in the pursuit of cluster industrial policy is the wrong choice of the control target due to information asymmetry, lack of statistics, and the absence of effective tools for recognising clusters and their prototypes (Babkin et al., 2011; Chain et al., 2019; Komorowski, 2020).

The key elements of the programme policy of cluster promotion are propaganda of specific industrial advantages in and outside a region aimed at improving the attractiveness and advancement of the environment where firms operate, consulting and providing specialised services, for example, in the field of finances, marketing, and designing; attracting new industrial investors, who can supplement regional value chains, or setting up start-ups to strengthen the system potential of a cluster (Kuzovleva et al., 2019).

Fromhold-Eisebith and Eisebith's (2005) theory about forms of cluster promotion and the results of my own research (Kudryavtseva, 2016) in part of the transformation of forms of cluster promotion and their transformation into state cluster policy form the basis of this study. Therefore, I developed a classification based on the ideas of Martina Fromhold-Eisebith and Gunter Eisebith (Figure 2). This approach was developed through the introduction of the second categorisation dimension, differentiating explicit and implicit cluster promotion, also thanks to institutional prerequisites. It is graphically presented as a transformation process of cluster promotion forms and their conversion into state cluster policy. The transformation process can start with private industrial initiatives, which can then be supported by local government bodies, and as a result, the implicitly ascending promotion form of industrial enterprises will convert to an implicitly descending promotion form. Perhaps, private industrial initiatives started at the local level will be supported by private industrial elites on the regional or federal level, and, thus, the implicitly ascending promotion form of industrial enterprises will turn into an explicitly ascending promotion form. Finally, supported either by local government bodies or by industrial associations at the regional level, cluster promotion will have the form of state industrial policy, which can be classified as an explicitly descending form of cluster promotion.

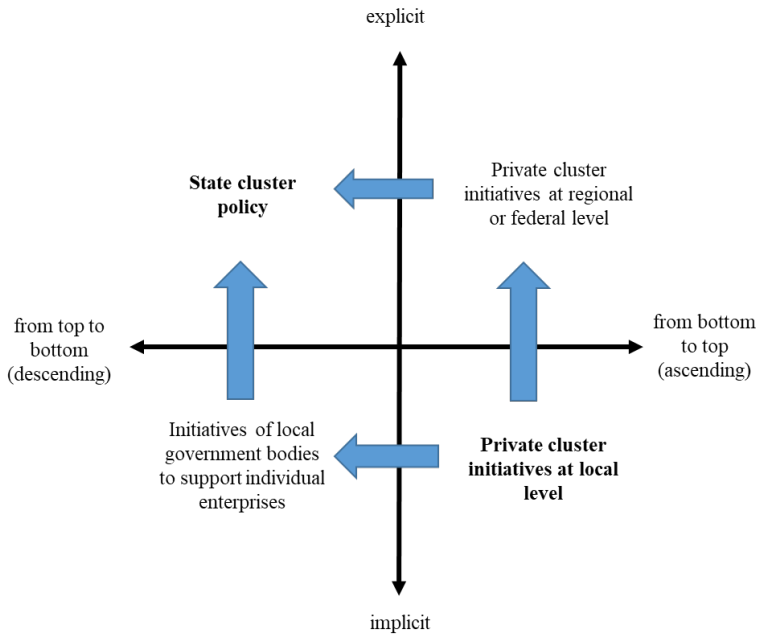

Figure 2 – Categorisation and transformation of cluster promotion forms
Source: composed by the author based on (Fromhold-Eisebith & Eisebith, 2005)

The suggested polarisation has a relation to classic "government-versus-market" arguments when "government-versus-industry" approaches are established. Nonetheless, ascending cluster promotion should not be equivalent to the effect obtained as a result of the action of purely market forces. On this point, descending and ascending initiatives address recognised market drawbacks, refer to the development of key cluster structures, and, in both cases, lead to active implementation of promotion measures. However, these activities are organised differently, depending on the forms that either rely on market mechanisms or on the state.

1.4 Cluster development in transitional economy

Clusters are part of the competitive environment of the economy (Ketels). Clusters have geographical boundaries, and cluster enterprises both compete and cooperate to solve individual tasks (Porter). Clusters in a transition economy have limited effectiveness, as the institutions of the market economy are at the stage of formation and function only in a limited way during the transition from a command economy to a market economy. Russia has been an example of a transition market economy since the 1990s. To date, some industry markets function effectively, and Russian enterprises compete in international markets, but most industry markets compete only at the local level. According to a study by Islankina and Thurner (2018), the main factors limiting the entry of Russian clusters into the international market are financial resources and the lack of qualified personnel, whereas cultural differences and geographical distances are much less important. However, Russia is a commodity economy, which also leads to the redistribution of resources in extractive industries and to the outflow of capital from industry (Ketels & Memedovic, 2008). In these conditions, the development of clusters

is limited, and the state cluster policy requires taking into account the above factors of the institutional environment of Russia.

It is also necessary to take into account that Russia's industrial policy was based on the formation of territorial production complexes for a long period (from 1930 to 1990). The main contribution to the science of the development of the theory of territorial production complexes (TPC) was made by N. Kolosovsky and his students. TPC is understood as "such an economic (mutually dependent) combination of enterprises in one industrial point or in the whole area, in which a certain economic effect is achieved due to a successful (planned) selection of enterprises in accordance with the natural and economic conditions of the area, with its transport and economic and geographical location" (Porosenkov, 2014). Using this theory, some large industrial complexes were created in the USSR: Timan-Pechora, Bratsko-Ust-Ilimsky, Sayan, West Siberian, Mangyshlak, Pavlodar-Ekibastuz, Karatau-Dzhambul, etc. (Agirrechu et al., 2004; Nesterova & Cherkasov, 2015). The main similarity between TPC and clusters is the geographical concentration of enterprises and their cooperation within the framework of vertical and horizontal integration, and the difference is the lack of competition in TPC.

In modern Russia, the historical trend of the high role of state influence on economic processes has been preserved. In this regard, various state programmes of cluster development and the support of cluster initiatives are being implemented at the federal and regional levels. Thus, in the context of the development of market economy institutions with the predominance of the commodity economy sector and on the basis of the long historical development of the TPC in Russia, a significant transformation of the industry structure is currently taking place, which requires the identification of regions of concentration of industries to form a cluster policy to obtain the positive regional effects (MAR) described in Section 1.2.

1.5 Current stage of research on clusters in Russia

Russian literature also includes works dedicated to analysing the status of Russia's cluster system as a whole and the development of clusters in individual regions. Thus, Manukyan analysed the potential of the oil and gas cluster in the Samara Region (Manukyan, 2015), Zemtsov and Barinova (2016) analysed the status and advancement of promising high-tech clusters. Nemchenko and Luzina (2018) considered the oil and gas cluster of Tumen Region as a tool for modernising the region's economy. Larichkin et al. (2011) analysed the case of the sea oil and gas sector in the territory of Murmansk Region. Islankina et al. drew up methodological guidelines for setting up and developing innovative clusters at the government level (Kutsenko et al., 2017). Khukhrin (2011) presented the analysis of the cluster policy concept in the agriculture of Russia from the position of a system and synergy approach, Vertakova et al. (2014) gave an example of a scheme for setting up a food cluster and an example of the organisational-economic cooperation structure in an industrial cluster. Markov et al. (2017) conducted a detailed analysis of the federal and regional cluster policy.

Only two large international projects are dedicated to automated calculation and further mapping of the results of the cluster development dynamics analysis for the purpose of monitoring and shaping cluster policy: US Cluster Mapping (Harvard Business School & U.S. Economic Development Administration, 2018) and European Cluster Initiative (Ketels & Protsiv, 2014). In Russia, there is a project called the "Russian Cluster Initiative" (HSE, 2019). However, in contrast to similar projects in the USA and the European Union, it presents information only about the location and main performance

results of the formal clusters supported by the government. Thus, the national project does not pay enough attention to analysing and identifying clusters, that is, to the general structure of the regional economy.

Developing, spreading, and applying digital technology to provide support for decision-making processes is one of the areas developing in the context of the transition to digital economy (Korolev et al., 2017; Okrepilov et al., 2015). Technical solutions in this area are aimed at implementing information-analytical systems supporting managerial decisions at all levels of the socioeconomic system: at the level of individuals (Mangusheva & Khairulin, 2017), enterprises (Budina & Kezhapkina, 2015), clusters (Chertina, Kvyatkovskaya, & Khomenko, 2017), sectors (Agafonov & Vashchenko, 2016), regions (Medvedev et al., 2016), and countries (Ageeva, 2018). Thus, it becomes necessary to develop specialised decision and management support systems for every level of the socioeconomic system.

The relevance of building the system is preconditioned by the need to monitor and analyse the advancement of regional clusters so that the impact individual sectoral and national programmes have on their development can be assessed (Gerlitz et al. 2020; Meyer, 2020). Moreover, this system must ensure the automatic identification of the latent clusters located in a region's territory, and these clusters must be supported in the same way as the formal clusters started by the government. Today, this system exists in the USA (Harvard Business School & U.S. Economic Development Administration, 2018) and the EU (Ketels & Protsiv, 2014). However, it has not been implemented in Russia. In addition, most research studies have focused on considering individual clusters in individual regions (see, for example, the works by the following authors: Larichkin et al., (2011); Manukyan (2015); Nemchenko & Luzina (2018); and others), rather than on analysing comprehensively the status of the regional cluster structure in Russia, such as in the works by Kudryavtseva and Skhvedian (2018), Islankina (2017), Zemtsova (2017).

2 RESEARCH METODOLODGY AND SETTING

Section 2 is dedicated to the description of the research methodology and its elaboration. First, I present and describe the research design for identifying and analysing the cluster structure of a territory. This framework answers the RQ1. Next, I briefly describe the developed database, which I used for cluster structure identification and analysis. Finally, I present the regression models and intuition behind them to answer RQ2.

2.1 Research design for cluster structure identification and analysis

Based on the literature review, I developed the research design, presented in Figure 3. This methodology was elaborated to study the cluster structure of territories to determine priority directions for industry clustering and ensure a growth of wealth due to the achievement of externalities from the localisation of cluster enterprises.

The cluster structure of territories is an agglomeration that includes interrelated and vertically and horizontally integrated industrial, infrastructural, and raw material cluster groups localised in a territory.

In the research study, I developed a methodology for identifying and analysing the cluster structure of territories at the micro- and macro-levels (Figure 3) in conditions of transition economy, which allows us to answer RQ1.

The first block is the analysis of sectoral features of clusters, which includes determining the sectoral composition of "standard" clusters and calculating the agglomeration, urbanisation, and concentration indicators. Agglomeration reflects the degree of non-uniformity distribution of the employed in a cluster in a territory. Concentration and urbanisation show the degree of attraction of cluster enterprises to joint localisation with each other and the degree of attraction to joint localisation with enterprises involved in any other type of activity, respectively. As a result of the analysis, clusters will be categorized as concentrated and dispersed, urban, and rural (Kudryavtseva, 2018; Rodionov & Kudryavtseva, 2016). The list of standard (reference) clusters on the basis of which the study was conducted is provided in Appendix 2. The need to use standard clusters was informed by the conditions of a transition economy, in which value chains created within the planned economy system have been destroyed, and new ones are at the stage of formation and are not stable and well-established.

The second block is the analysis of economic parameters of a region's clusters, which includes identifying strong clusters, that is, cluster groups having enough "critical mass" to produce positive agglomeration effects. According to the methodology developed by the European Cluster Observatory, a cluster is considered localised in a region if it meets at least two factors out of three – localisation coefficient, focus, and size (Kudryavtseva & Olaniyi, 2019; Kudryavtseva et al., 2018). The localisation coefficient shows how many times the share of employed in the cluster exceeds the average number of employed in the country; the size is the share of employed in the cluster in the region in comparison with the employed in the cluster countrywide; and the focus of the cluster is the share of employed in the cluster in comparison with the total number of employed in the region.

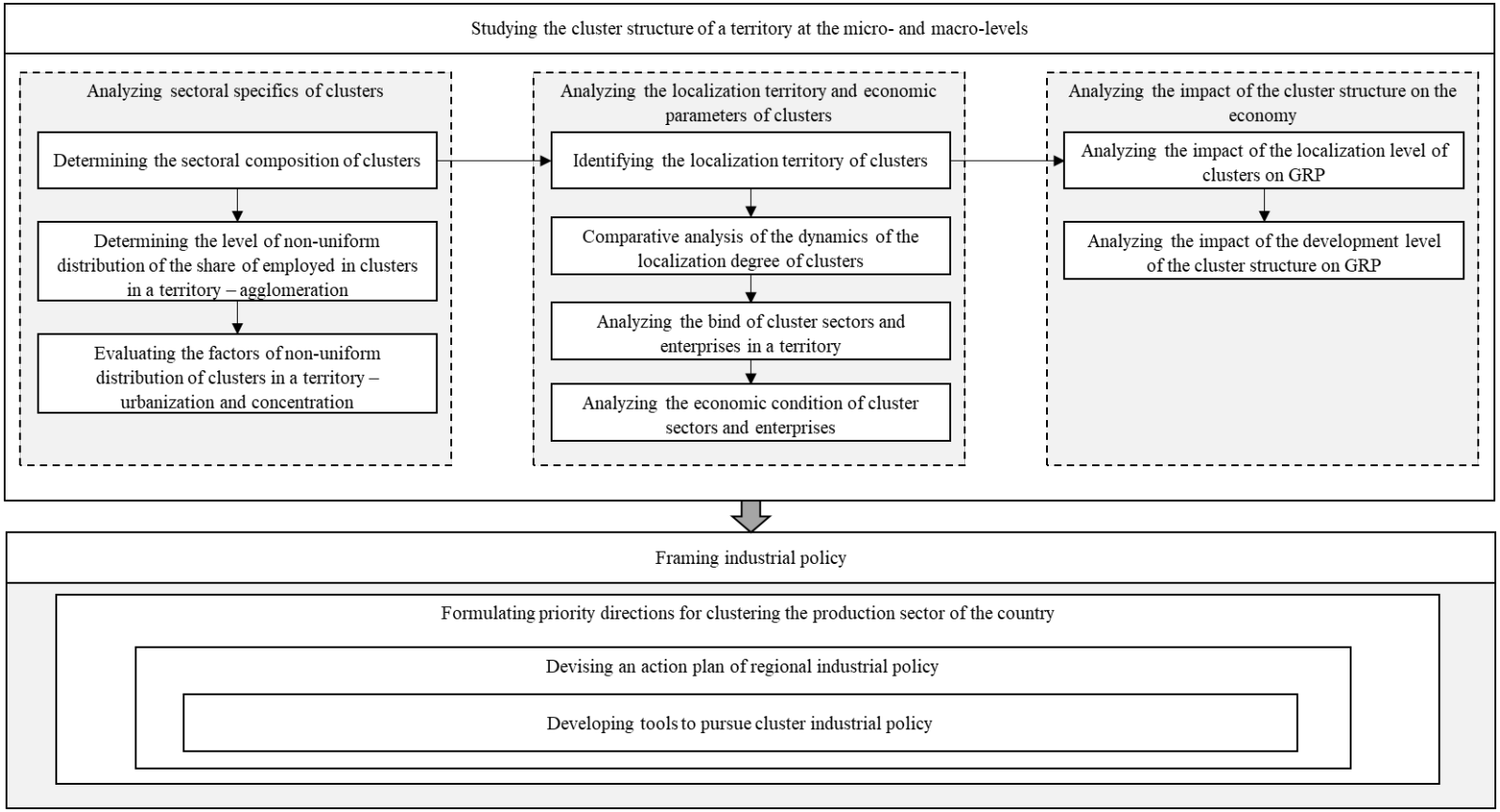

Figure 3 – Research design for the identification and analysis of the cluster structure of a territory
Source: composed by the author

This stage will allow us to determine the regions of localisation of industries, that is, the cluster structure of territories, on the basis of which the changed or transformed structure of industries in the regions during the transition to a market economy can be analysed. This block is supplemented with (1) a comparative analysis of the dynamics of regional cluster localisation, bind of regional clusters, and economic condition of clusters, which allows us to define the main development trends of the studied clusters; (2) competing concentration regions of cluster sectors, capable of affecting the employment of other cluster groups due to more significant positive agglomeration externalities in their territory; (3) clusters with a single sectoral belonging of its enterprise structure in the context of vertical and horizontal integration; and (4) economic performance indicators of cluster enterprises.

The third block involves identifying positive agglomeration effects due to the assessment of the impact produced by the level of cluster localisation in a region on economic growth based on econometric analysis methods (Kudryavtseva & Olaniyi, 2019; Kudryavtseva et al., 2018). This stage will allow us to identify clusters that give positive regional localisation effects – MAR – and can be potential objects of state investment programs. Thus, the increased specialisation of the region in the supported type of activity will ensure the economic growth of the region.

Therefore, as the theoretical contribution of the research, I developed methodological tools to research the cluster structure of territories at the micro- and macro-levels, including analysis of sectoral specifics, localisation territory, and economic parameters of a cluster, evaluation of the impact of the cluster structure of a territory on the economy aimed at forming priority directions for industry clustering, measures, and tools of industrial policy. The proposed methodology is based on the application and study of methodological approaches of the leading national and foreign schools (Porter, European Cluster Observatory, and Russian Cluster Observatory) and using a convergence approach. Cluster industrial policy can be framed based on the obtained information.

2.2 Data collection and measurement

To determine the regions where the cluster localises, a **database called "Clusters of Russia's regions" was created** (state registration certificate RIA No.2017620569 of May 29 2017). The developed database is a tool for studying the cluster structure of the Russian economy and one of the answers to **RQ1**. In terms of its functions, it is analogous to the US Cluster Mapping US Cluster Mapping (Harvard Business School & U.S. Economic Development Administration, 2018) and European Cluster Initiative (Ketels & Protsiv, 2014). As a result of database application, I used statistical properties of clusters in Russian regions to estimate the effect of industrial clusters on the economy of Russian regions, calculated by database, and answer **RQ2**. I also used a database to identify the cluster industrial structure of Russia and St. Petersburg and answer **RQ3**.

The database was designed to determine the regions of cluster localisation using data on the population employed in various types of activity (Kudryavtseva et al., 2020). To implement the suggested approach, statistic databases were established on the number of employed and the quantity of enterprises in the Russian regions, grouped according to the cluster cores for the years 2008–2016. To group the types of activity by clusters, a classification developed by Porter was used, and correspondence was established between such classifier codes as SIC, NACE, and OKVED (Russian Classification of Economic Activities) (Appendix 2).

As a result of this adaptation of the core, 37 cluster groups were filled with the types of economic activity according to 4-digit OKVED codes, considering the available detailed data. According to a certain composition of clusters, statistical databases were set up on the number of enterprises and organisations for the year 2016 and the number of employed in cluster groups for the years 2008–2016 in 83 Russian regions.

Applying the database allowed us to achieve four major goals:

- Minimising the storage of large volumes of information about the employed population by years and types of activity.
- Ensuring comfortable input and editing of information about the employed population of the regions
- Creating a computational tool for evaluating the employment dynamics in Russian regional clusters by years.
- Processing the information obtained as a result of computation in an analytical manner, selecting significant clusters according to the set criteria in each region of Russia.

2.3 Econometric modelling for evaluating the impact of industrial clusters on the economies of regions

To carry out the third phase of analysis of the cluster structure of territories, economic tools were used to evaluate the impact of industrial clusters on the economies of regions (Kudryavtseva & Olaniyi, 2019). As a result, agglomeration effects or Marshall's externalities (Slaper et al., 2018) affecting the economic growth of regions were assessed. The econometric problem was formulated as an assessment of the bind between the level of cluster localisation in the Russian territory and the dynamics of gross regional product – RQ2.

The analysis was performed in two phases – 3.1 and 3.2. In phase 3.1, I evaluated the binding of industrial clusters and GRP level. In phase 3.2, I measured the interrelation between the development level of the cluster infrastructure and the size of the GRP, that is, the amount of multiplication effect from cluster localisation in the region. The study was conducted by econometric analysis methods using regression analysis tools of panel data available in STATA MP14 software.

3.1. In the first phase of the study, hypotheses were tested regarding the binding between the presence of cluster *j* in region *i* and the size of its GRP. The following models were built to check these hypotheses:

$$\ln\mathrm{GRP}_{\mathrm{it}} = \beta_0 + \beta_{\mathrm{i}}\mathrm{Cluster}_{j\mathrm{it}} + \varepsilon_{\mathrm{jit}} \quad (1)$$

$$\ln\mathrm{GRP}_{\mathrm{it}} = \beta_0 + \beta_{\mathrm{i}}\mathrm{Cluster}_{\mathrm{jit}-1} + \varepsilon_{j\mathrm{it}} \quad (2)$$

$$\ln\mathrm{GRP}_{\mathrm{it}} = \beta_0 + \beta_{\mathrm{i}}\mathrm{Cluster}_{ji t=2011} + \varepsilon_{\mathrm{jit}} \quad (3)$$

$$\ln\mathrm{GRP}_{\mathrm{it}} = \beta_0 + \beta_1\ln\mathrm{RIiFA}_{\mathrm{it}-1} + \beta_2\ln\mathrm{TRE}_{\mathrm{it}} + \Upsilon_{\mathrm{i}}\mathrm{ClusterIT}_{\mathrm{it}} + \phi_{\mathrm{t}}\mathrm{Year}_{\mathrm{t}} + \varepsilon_{\mathrm{it}} \quad (4)$$

$$\ln\mathrm{GRP}_{\mathrm{it}} = \beta_0 + \beta_1\ln\mathrm{RIiFA}_{\mathrm{it}-1} + \beta_2\ln\mathrm{TRE}_{\mathrm{it}} + \Upsilon_{\mathrm{i}}\mathrm{LQ}_{\mathrm{it}} + \phi_{\mathrm{t}}\mathrm{Year}_{\mathrm{t}} + \varepsilon_{\mathrm{it}} \quad (5)$$

$$\ln\mathrm{GRP}_{\mathrm{it}} = \beta_0 + \beta_1\ln\mathrm{RIiFA}_{\mathrm{it}-1} + \beta_2\ln\mathrm{TRE}_{\mathrm{it}} + \Upsilon_{\mathrm{i}}\mathrm{Size}_{\mathrm{it}} + \phi_{\mathrm{t}}\mathrm{Year}_{\mathrm{t}} + \varepsilon_{\mathrm{it}} \quad (6)$$

$$\ln\mathrm{GRP}_{\mathrm{it}} = \beta_0 + \beta_1\ln\mathrm{RIiFA}_{\mathrm{it}-1} + \beta_2\ln\mathrm{TRE}_{\mathrm{it}} + \Upsilon_{\mathrm{i}}\mathrm{Focus}_{\mathrm{it}} + \phi_{\mathrm{t}}\mathrm{Year}_{\mathrm{t}} + \varepsilon_{\mathrm{it}} \quad (7)$$

where $\ln GRP_{it}$ is the natural logarithm of GRP (rubles, at constant prices of year 2011) generated in region *i* at time *t*;

$Cluster_{jit-1}$ is the binary variable that takes a value of 1 or 0, depending on whether the presence of cluster *j* was or was not registered in region *i* at time t-1.

$Cluster_{jit=2011}$ is the binary variable that takes a value 1 or 0, depending on whether the presence of cluster *j* was or was not registered in region *i* in 2011.

$Cluster_{jit}$ is the binary variable that takes a value of 1 or 0, depending on whether cluster *j* was or was not localised in region *i* at time *t*;

$\ln RIiFA_{it-1}$ is the natural logarithm of investment (rubles, at constant prices of year 2000) in fixed capital made in region *i* at time t-1;

$\ln TRE_{it}$ is the natural logarithm of the number of employed (mil. people) in region *i* at time *t*;

$ClusterIT_{it}$ is the binary variable that takes the value 1 or 0 depending on whether the region has the "information technology" cluster or not;

LQ_{it} is the size of the localisation coefficient of the "information technology" cluster in region *i* at time *t*.

$Size_{it}$ is the size of cluster group *i* at time *t*, in %.

$Focus_{it}$ is the focus of cluster group *i* at time *t*, in %.

$Year_t$ are the binary variables that take the value 1 or 0, depending on whether the observation refers to concrete year *t* or not;

ε_{jit}, ε_{it} is the random variable specifying deviations of the real value of the effective sign from the value of the regression equation;

β_0 is the constant.

3.2. In the second phase, according to the model suggested by G. Lindqvist (2009), analysis is carried out to measure the effect produced by the region's cluster structure on the amount of GRP. Hypotheses are checked to see if there is dependence between the development level of the cluster structure in region *i* and the size of the GRP at different moments of time. Models used for testing the hypotheses are as follows:

$$\ln GRP_{it} = \beta_0 + \beta_i Dev\_of\_cluster_{it} + \varepsilon_{it} \quad (8)$$

$$\ln GRP_{it} = \beta_0 + \beta_i Dev\_of\_cluster_{it=2011} + \varepsilon_{it} \quad (9)$$

$$\ln GRP_{it} = \beta_0 + \beta_i Dev\_of\_cluster_{it-1} + \varepsilon_{it} \quad (10)$$

where $Dev\_of\_cluster_{it}$ is the variable that shows the general development level of the cluster structure of the economy of region *i* at time *t*. This variable is calculated by adding "stars" obtained by all cluster groups j in the region at time t according to the results of evaluation of the "Localisation Coefficient", "Cluster Size", and "Cluster Focus". According to Lindqvist (Lindqvist, 2009), this approach makes it possible to illustrate the specialisation level of the region and the development of its cluster structure.

$Dev\_of\_cluster_{it-1}$ is the variable that shows the general development level of the cluster structure of region *i* in time t-1.

$Dev\_of\_cluster_{it=2011}$ is the variable that shows the general development level of the cluster structure of the economy of region *i* in year 2011.

3 Results, discussion, and implications

Section 3 provides the quantitate results of the research. I applied the developed in Chapter 1.4 concept and mechanism of cluster industrial policy and developed with the methodology in Section 2 to the case of Russian regions. Therefore, I fill the research gap regarding the identification of cluster industrial structure in Russian regions, show the results of application of the developed database for all Russian regions, and discuss in detail the case of St. Petersburg.

3.1 Identification and analysis of cluster structures in Russia's territory

To test the methodology for identifying and analysing the cluster structure of a territory (Figure 3), clusters were identified by the federal subjects. See another example of the database application in the article by Kudryavtseva et al. (2020).

In the first phase of the study, I calculated the agglomeration coefficient with the aim of revealing the specifics of the sectoral structure of cluster groups affecting the spatial concentration. This indicator, which characterises the non-uniformity of distribution of the employed in cluster groups by the federal subjects, allowed us to assess the level of cluster concentration in the territory of Russia.

First, I calculated the concentration and urbanisation indicators on the basis of statistics about the number of enterprises by federal subjects and types of activity. Next I identified cluster groups whose enterprise concentration within a region or a subject of Russia was caused by striving to be jointly located with similar enterprises or by an inclination to be based in territories with a high density of enterprises involved in any types of activity. In other words, we identified cluster groups whose joint localisation was preconditioned by the presence of various groups of agglomeration externalities: Marshall's externalities or Jacobs' externalities (Caragliu et al, 2016). According to the existing positive or negative Marshall's externalities and Jacobs' externalities, all clusters were categorised as concentrated or dispersed, and urban or rural (Figure 4). Thus, for example, the concentrated urban cluster groups – "Information Technology", "Science and Education, "Media and Printing", and others – experienced considerable positive effects from being in close proximity to each other and to enterprises involved in any other types of activity. These clusters had the strongest potential for development in regions with a high density of population and significant economic activity.

The main trends observed in the degree of cluster concentration and dominance of certain agglomeration effects resulting in this concentration have a universal nature and are true for the cluster structure of many countries.

In the second phase of the research study, I highlighted cluster groups of each federal subject whose cores had enough strength to have and develop positive agglomeration effects. As a result of the application of the database, the cluster structure was defined for 83 regions of the Russian Federation, and localisation maps were built for 37 clusters in the territory of Russia during the period from 2008 to 2016 (**RQ3**).

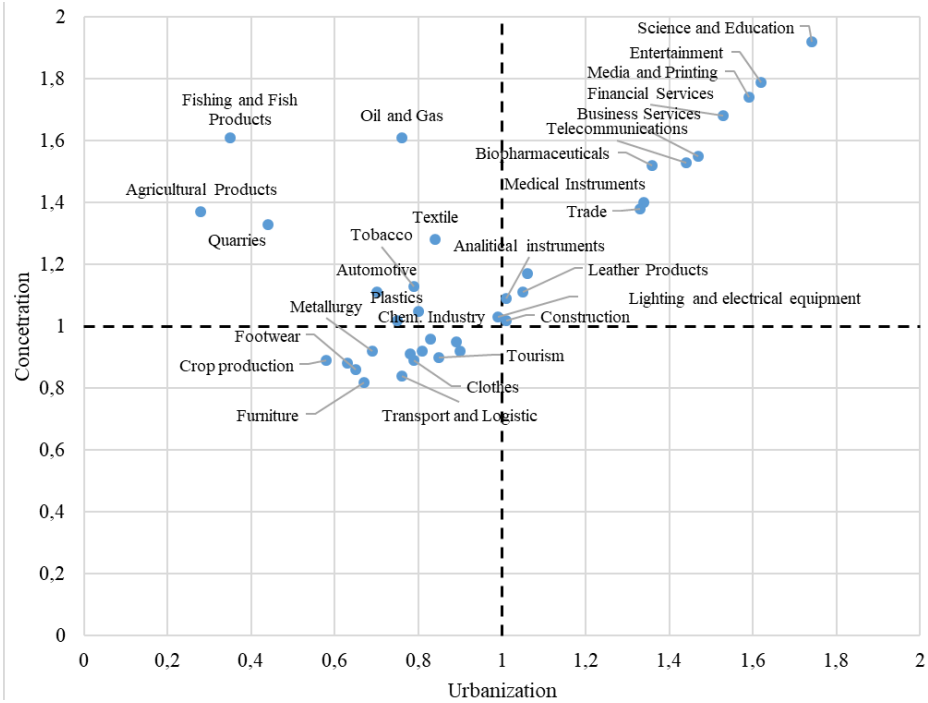

Figure 4 – Classification of Russian clusters by level of concentration and urbanisation
Source: composed by the author

For example, in 2016, the industrial cluster "Information Technology" was presented in the following regions – St. Petersburg, Moscow, Yaroslav Region, Novosibirsk Region, Tatarstan, and Penza Region (Figure 5). The cluster is biggest in the cities of Moscow and St. Petersburg, with 30.52% and 16.14% of the total number of employed individuals found in the cluster in Russia. However, the focus of the cluster – the share of the employed in the cluster in relation to the total number of the employed in the region – reduced in Moscow from 43.87% to 30.52%, and increased in St. Petersburg from 10.52% to 30.52%. Over the period considered, the concentration of the cluster in large cities and regional centres grew. The cluster was localise in the Kursk and Kaluga Regions.

According to the tested hypothesis about a dependence between the presence of cluster j in region *i* and the size of its GRP, the following main results were obtained. Industrial clusters in Russia, such as as "Automotive Industry", "Analytical Tools", "Aerospace Engineering", "Biopharmaceuticals", "Information Technology", "Metallurgical Industry", "Plastics", "Production Equipment", and "Chemical Industry", had a positive impact on the size of GRP in the long run (**RQ2**). See the detailed description and results in the article by Kudryavtseva and Olaniyi (2019). Only individual clusters had a positive regional effect, as the market infrastructure was not sufficiently developed, which is also discussed in this study (Ketels & Memedovic, 2008).

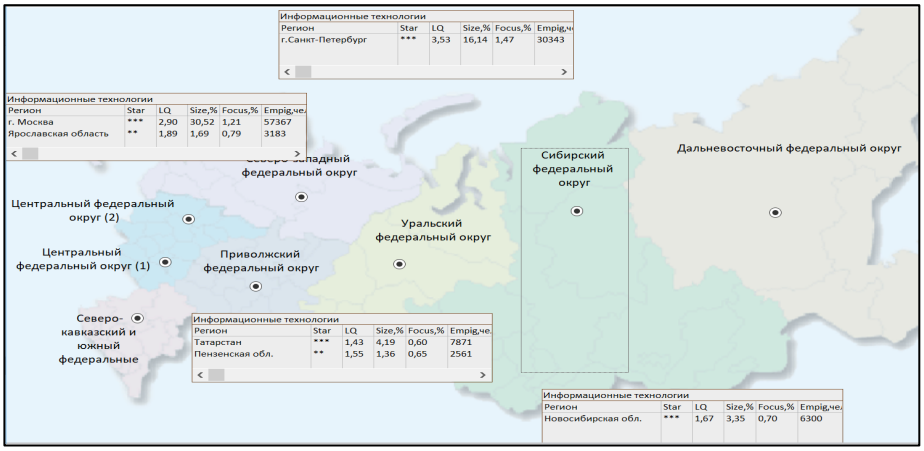

Figure 5 – Values of localisation indicators of the information technology cluster in Russian territory in 2016
Source: composed by the author

The analysed influence of the localisation of the "Information Technology" cluster showed that in the regions where the value of the cluster localisation coefficient was higher by 1 unit at time *t*, the level of GRP was, on average, 11.1% higher. When the size of the cluster was higher by 1 percentage point at time *t*, the level of GRP was, on average, 2.52% higher. In clusters with a focus with 1 percentage point higher at time *t*, the level of GRP was, on average, 30.3% higher. The obtained results can be interpreted as agglomeration effects of the "Information Technology" cluster (**RQ2**). See the detailed description and results in the article by Kudryavtseva et al. (2018).

According to the tested hypothesis regarding the dependence between the development level of the cluster structure in region *i* and the size of GRP in the current period and in a long-term period (compared to year 2011), a meaningful positive dependence was obtained between the development level of the cluster structure of regions and the size of their GRP in both the short-term and long-term periods (**RQ2**). See the detailed description and results in the article by Kudryavtseva and Olaniyi (2019).

3.2 Measures of St. Petersburg regional cluster policy

The St. Petersburg region is an industrial and research centre that has had a long history of development since the 18th century. The first Russian universities and large industrial enterprises whose activities were integrated into the TPC, which made it possible to produce knowledge-intensive and capital-intensive products, are represented here. St. Petersburg is a good case for assessing the effects of the development of the competitive environment, as a result of which the established value chains were first broken during the development and production of products in the 90s, and then the formation and development of a new cluster structure of the region took place.

The dynamics of the sectoral cluster structure of St. Petersburg were assessed for the period from 2008 to 2016, and the factors limiting the development of the production industry were identified (**RQ3**).

Throughout the entire period from 2008 to 2016, St. Petersburg was the region where the following clusters were localised: industrial clusters: "Information Technology", "Biopharmaceuticals", "Analytical Tools", "Lighting and Electrical Equipment", "Tobacco";

and infrastructural clusters: “Science and Education”, “Energy Production and Transmission”, and “Trade.”

The analysed dynamics of the absolute number of employed by cores of cluster groups allowed us to draw conclusion about structural change in the economy of the region. It was defined that the trend towards reducing the number of employees is common for the majority of industrial clusters in St. Petersburg, apart from high-tech and science-intensive cluster groups, which demonstrate an increase in the number of employed.

The strength dynamics of the developed cores of St. Petersburg clusters were analysed in detail, including research into the changes in relative abundance used to determine the important clusters of the Russian regions. The study included identifying the competing “focal points” of concentrated enterprises of the relevant cluster group in other Russian regions.

As a result, the following conclusion can be drawn about a fairly well-developed cluster structure in St. Petersburg. In 2008, there were two related meta-cluster groups in the region – one concentrated around the “Science and Education” cluster, while the other referred to “Lighting and Electrical Equipment” (Appendix 3). In 2012, the cluster group became more advanced – there appeared a single science-intensive meta-cluster group due to the progress of the industrial cluster “Analytical Tools.” (See initial results for 2012 in T. J. Kudryavtseva (2016) and T. Kudryavtseva & Jurievna (2015); Appendix 3). In 2016, the region demonstrated further progress in the cluster structure – the science-intensive meta-cluster group expanded due to the industrial cluster “Medical Instruments” (Appendix 3, Figures 6). This meta-cluster group can be specified as an innovative one thanks to the concentration of high-tech production facilities in the field of instrument engineering and power engineering. Not only industrial but also infrastructural clusters, such as “Tourism”, “Trade”, and “Business Services”, were developing in the region.

To determine the institutional forms of cluster promotion presented by Fromhold-Eisebith and Eisebith and described in Section 1.3, as well as supplemented by me in Appendix 5, the cluster groups of the St. Petersburg region supported at the federal and regional levels were identified (see Appendix 4) and correlated with the identified significant clusters of the region as of 2016 (see Figure 6).

Based on the results of the analysis, it can be concluded that all significant industrial clusters localised in the region were supported at the federal level. Therefore, in accordance with the classification in Appendix 4-5, they were characterised as explicitly descending, that is, existing in the region and promoted by the state. Most clusters supported by regional authorities did not have sufficient concentration strength in the St. Petersburg region compared to other regions in Russia. Thus, they were characterised as implicitly descending, that is, clearly not existing in the region but supported by the regional authorities. There were also many infrastructure clusters in the region, but the clusters considered by the state as an object of cluster policy were Science and Education, Trade, Business Services, and Tourism. These clusters can be characterised as explicitly ascending, that is, clearly localised in the region but developing without the participation of the state.

The institutional forms of cluster promotion in St. Petersburg are identified; the measures of St. Petersburg cluster industrial policy aimed at overcoming the limitations are substantiated in detail by all groups of the region’s clusters.

Comparative analysis of the clusters localised in St. Petersburg and supported at the federal and regional levels in 2016 allowed us to assess the clusters that explicitly descending, explicitly ascending, and implicitly descending forms of cluster promotion (Figure 6).

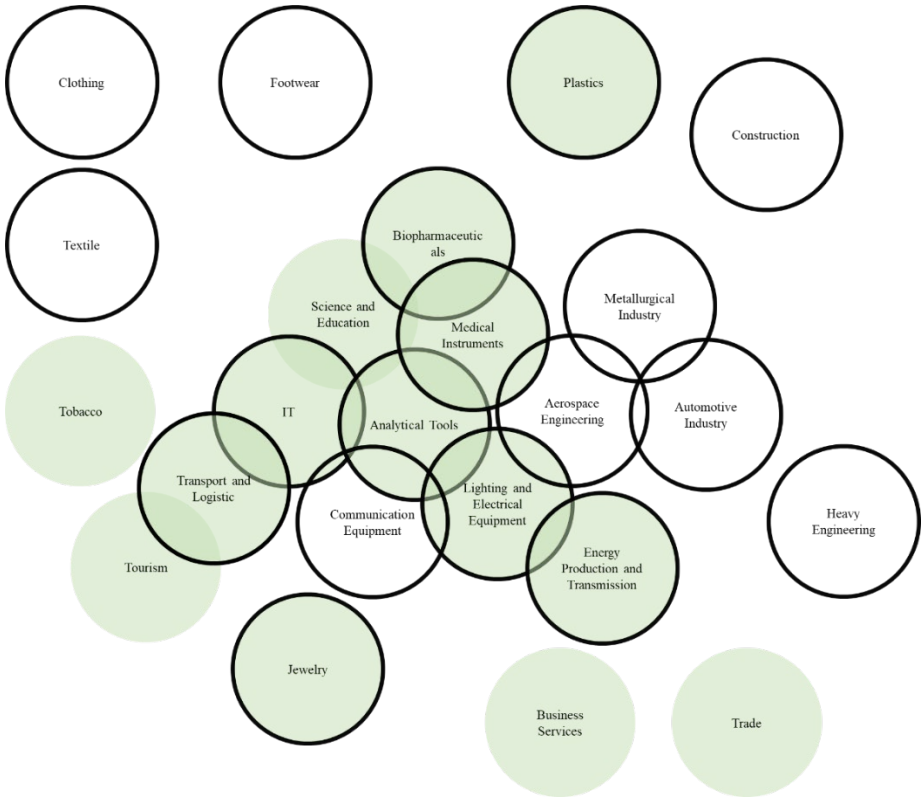

Figure 6 – St. Petersburg cluster map in 2016, which takes into account state programmes for regional cluster promotion. Explicitly descending clusters, that is, localised in the region and promoted by state—highlighted in green and encircled; explicitly ascending clusters, that is, localised in the region and not promoted by state—highlighted in green; implicitly descending clusters, not localised in the region and promoted by state—encircled.
Source: composed by the author

To evaluate the condition of the industries that form the cluster structure of a region, we analysed the labour security analysis of the cores of the cluster groups, the efficiency of fixed assets use, and the maturity of related cluster groups, which ensure and maintain the activity of cluster enterprises. According to the results obtained for each core of a cluster group, we highlighted the industries in which industries where actions need to be taken to increase labour security and raise industrial potential. We also pointed out related cluster groups whose development will strengthen the considered cluster cores.

Three directions for state support measures are suggested to develop St. Petersburg cluster structure with the help of industrial policy: (1) increasing the labour security of cluster industries and investing in training professionals in relevant fields; (2) improving the industrial potential of cluster industries with more efficient use of fixed production assets due to modernisation of production and technology base and investment into

innovative technologies; (3) developing related cluster groups embracing both main suppliers of materials, equipment, etc., and enterprises using similar technologies. The details of individual measures to be taken for all groups of the region's clusters for each of the suggested directions are provided in Appendix 6.

3.3 Discussion of results and implications

The developed research methodology of a territory's cluster macrostructure was based on the theoretical assumptions according to which spatial localisation of industrial clusters is the essence of a market organised in the best way, while growth in wealth due to the clustering of economic sectors is achieved if a country (region) has a natural comparative advantage. The research methodology of a territory's cluster macrostructure **(RQ1)** included analysis of sectoral specifics of clusters, analysis of localisation territory, economic parameters of clusters, and analysis of the impact of cluster structure on the territory's economy. It provided consistent algorithms and tools that can be applied for cluster identification and analysis at macro-, meso- and micro levels. Applied tools of algorithmisation and automation were elaborated to research the cluster structure of territories – the database "Clusters of Russia's Regions". This was used to determine the cluster structure of 83 Russian regions and to build localisation maps of 37 clusters in Russian territory during the transition period from 2008 to 2016. This result is essential because researchers, especially those in Russia, usually take into account only one level. See, for example: (Nemchenko & Luzina, 2018; Schepinin et al., 2018) and etc.

Next, I present the classification of Russian clusters by the level of concentration and urbanisation. This result follows the idea presented by Lindqvist (2009) for the European countries case. This results allows us to classify the cluster by categories and make conclusions, which can be taken into account during cluster industrial policy elaboration. For example, if a cluster can be classified as Concentrated Urban, then it is mostly effective in high-density territories and big cities. This suggests that the state should enhance the specialisation of the regions on these clusters to obtain positive externalities for the whole region from their concertation. However, there were dispersed rural clusters, which were located far from the big agglomerations and near closely related enterprises. These results are important for the case of Russian regions because, previously, there was no such extensive research on Russian cluster classification. Further, it provides the first element of the evidence-based approach to policymaking, which I implemented in my mechanism. After that I present results from regression analysis, which state that the higher the specialisation of the region, the higher its economic development. Detailed results and their discussion are presented in the article by Kudryavtseva and Olaniyi (2019)**.** These two findings partly answer **RQ2** and **RQ3**.

Next, to answer **RQ2** and **RQ3,** I draw the example of St. Petersburg to show how the mechanism and the methodology can be applied for concrete region. I present the cluster industrial structure of St. Petersburg, draw connections between the clusters in accordance to the relations presented in Harvard Business School & U.S. Economic Development Administration (2018) and recommend directions for measures of St. Petersburg state cluster policy (Appendix 6). Based on the results of the analysis of Section 3.2, namely, that there is no implicitly ascending form of cluster promotion, it can be concluded that all private cluster promotion initiatives were supported by regional authorities and thus evolved (see Figure 2) into an implicitly descending form of cluster promotion. This trend can be assessed as positive, but it was associated with the

risk of poor performance in regional industrial policy. The similar situation was modelled in detail in Section 3.2 (Figure 6, Appendix 4, 5), in which the cluster was supported in a region that did not have a comparative advantage over other regions of the Russian Federation. This part is significant to the scientific field because it shows which measures should be applied for each cluster depending on its' characteristics (Appendix 6). Therefore, it is an example of the evidence-based measures that should be applied to the development of the cluster structures in a specific region using the proposed by the author methodology and classification presented in Appendix 5.

Therefore, taking into account empirical and theoretical results, it can be concluded that cluster industrial policy in Russia was usually performed by the state government without the use of a clear and consistent informational and analytical background. This implies, that state programmes, which aim at development of the territories, did not always take into account the current situation in the regions (Kozonogova et al., 2019; Zemtsov et al., 2017). Therefore, these programmes supported certain industries that even did not exist in regions (Babkin et al., 2013). Thus, I concluded that official cluster policy should be aimed at supporting explicitly descending clusters, since these clusters will ensure the biggest long-term regional Marshall's externalities in the region.

In this regard, I have developed the mechanism of cluster industrial policy in the transition economy as the answer to **RQ4**. The mechanism reveals relations between objectives, methods, and elements of cluster industrial policy. This implies, that development of the cluster industrial policy should address concrete aims and use special tools. This idea comes from the Delgado et al. (2015), Ketels and Memedovic (2008), and Ketels and Protsiv (2014), who emphasized that each region has a unique cluster structure and if it can be identified, then it can be managed properly. Therefore, this result contributes to the cluster theory as a whole and to the cluster industrial policy elaboration for the Russian case in particular. This makes it important for Russia, because currently there are no tools that can provide a solid quantitative background for decision making.

The mechanism developed in this research study includes theoretical and methodological principles, presented in Chapters 1 and 2, and empirical results, presented at Chapter 3. In my opinion, cluster industrial policy represents a set of legal, economic, organisational, educational, informational, social, infrastructural, and other measures of state influence on industrial activity of clusters aimed at developing competitiveness and raising localisation of cluster enterprises in a territory to achieve a clustering effect – growth in the wealth of population in a territory. The developed mechanism of cluster industrial policy includes the objectives, principles, tools, and components of cluster industrial policy (Figure 7). This result is a theoretical contribution to the field and corresponds to **RQ4**.

The developed mechanism of cluster industrial policy is based on the following framework elements: priority cluster directions of an industrial country, actions, and tools of cluster industrial policy. Reciprocity of all elements of the mechanism of cluster industrial policy brings about a positive synergy effect, which is expressed in Marshall's externalities from the interaction of enterprises of a cluster and ensures the growing wealth of the population of a territory. Priority directions for the clustering industry are determined based on the studied cluster macro-structure of a territory, including the analysed localisation level of enterprises of a cluster in the territory and their comparative advantages. Regional cluster industrial policy is framed based on the research of coherence, effectiveness, and resource availability of clusters in a region, and

the institutionalisation of the promotion forms of clusters in the region. The tools of cluster industrial policy are determined by analysing the integrity of the structure of an industrial cluster, as well as the coherence, efficiency, and resilience of enterprises of the industrial cluster.

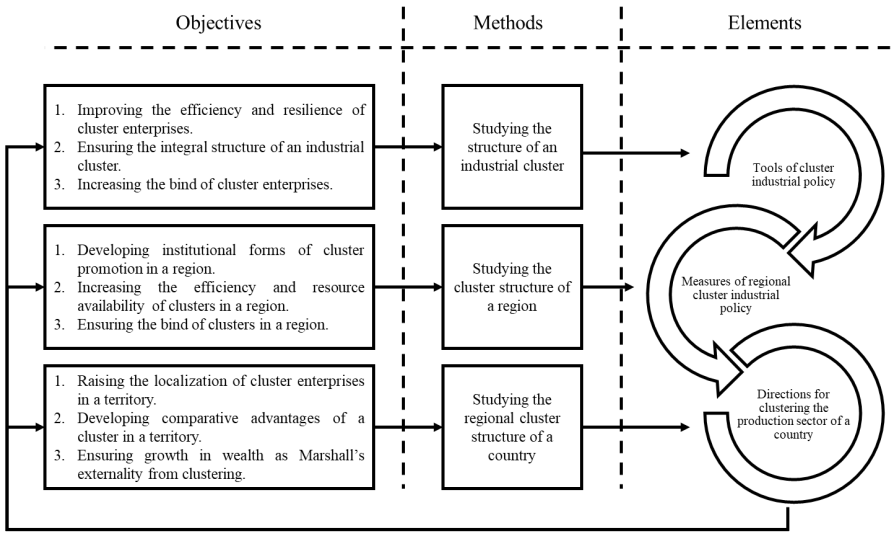

Figure 7 – Mechanism of cluster industrial policy in the transition economy
Source: composed by the author

I believe that an effective mechanism for industrial policy must follow all the principles of systems theory. The following principles can be defined in systems theory: consistency, communicativeness, integrity, hierarchy, equifinality, and feasibility (Blauberg et al., 1969). Based on the developed mechanism of cluster industrial policy, I propose the following interpretation of systems theory principles.

The law of consistency refers to the interaction of all elements of the mechanism of cluster industrial policy that gives a positive synergy effect, which is expressed in Marshall's externalities resulting from the interactions of cluster enterprises and ensures that the wealth of the population in a territory grows.

The law of communicativeness suggests that the mechanism of cluster industrial policy must be considered as a subsystem of a higher order system. Consequently, cluster industrial policy should be framed with due consideration of the institutional environment of the transition economy, determining the priority direction for the development of the national economy, and satisfaction of social needs. The industrial policy of every country's system has its specifics, which is confirmed by the analysis of the policies of developed countries.

The law of integrity posits that the mechanism of cluster industrial policy is based on the following framework elements, which were identified in the course of this research: priority directions of industry clustering, historical places of industry localisation, measures of regional cluster policy, and tools of cluster industrial policy. The priority directions of industry clustering are determined based on the study of the cluster macro-structure of a territory, which includes analysis of comparative advantages from locating cluster enterprises in the territory and the level of their localisation. Measures

of regional cluster industrial policy are formed based on research into consistency, efficiency, and resource availability of clusters in a region, and institutionalisation of cluster promotion forms of the region. Tools of cluster industrial policy were determined through analysing the consistency of the structure of an industrial cluster, bond, effectiveness, and resilience of enterprises of the industrial cluster.

The law of hierarchy refers to the consistency of a complex hierarchical system that is revealed at every level of hierarchy. In this case, it implies that the priority directions of production sector clustering, measures, and tools of cluster industrial policy are also complex subsystems. Thus, industrial policy is an element of state economic, social, environmental, and other state policies, as well as regional policy; that is, it is an element of a multi-level system of public administration.

The law of equifinality is revealed in the marginal capabilities of tools and measures of cluster industrial policy applied in a country or a region to ensure growth in wealth without cardinal change in the mechanism of cluster industrial policy. In the context of the transition from planned to market economy, the elements of the mechanism of industrial policy have to adapt and advance continuously.

The law of feasibility describes the degree of diversity of the mechanism of cluster industrial policy that must exceed the degree of diversity of the controlled system, that is, cluster enterprises. Consequently, to ensure growth in wealth, the state should use measures and tools of cluster industrial policy and consider all aspects of the activity of cluster enterprises, including regional, sectoral, and institutional ones.

Thus, the methodology of cluster industrial policy framing includes research into the cluster structure of a territory and the structure of an industrial cluster (Figure 2). Therefore, as the theoretical contribution of the research, I elaborate on the notion of cluster industrial policy and propose the mechanism of cluster industrial policy in a transition economy, which includes objectives, principles, tools, and its components.

Conclusion

Thus, in this research, I developed the theory, methodology, and tools of cluster industrial policy in a transition economy and elaborated the elements of a cluster-based mechanism of effective industrial policy tested on the example of St. Petersburg.

The following are the theoretical contributions of the research:

1. As a result of the summarised theoretical approaches to cluster forming and development, namely institutional theory, theory of regional development, and cluster theory, based on the principles of system analysis, the notion of cluster industrial policy was interpreted, and a mechanism of cluster industrial policy in transition economy, including objectives, principles, tools, and its components, was elaborated. This mechanism takes into account the institutional peculiarities of countries with transitional economies. These peculiarities are determined by the historical localisation of the industries and changes in the links between them in conditions of the market economy.

2. The economic structure of the region changes under the pressure of the market. Since it is unstable, the government should constantly monitor its development to manage these changes. Based on the application and study of methodological approaches of the leading national and foreign schools (Porter, European Cluster Observatory, Russian Cluster Observatory) and using a convergence approach, I developed methodological tools to research the cluster structure of territories at the micro- and macro-levels. This included an analysis of sectoral specifics, localisation territory and economic parameters of a cluster, evaluation of the impact of the cluster structure of a territory on the economy aimed at informing priority directions for industry clustering as well as measures and tools of industrial policy for transition economy. Cluster industrial policy can be framed based on the obtained information. The developed methodology allows for identifying regions of industry localisation, estimating the influence of clusters on gross regional product and economic growth, and supporting competitive value chains.

3. In conditions of a transition economy, industries integrate into global value chains, which leads to the destruction of the uncompetitive industries. This requires the development of tools for monitoring and analysing the regional cluster structure. Methodological tools were suggested and tested for algorithmisation and automation of research into the cluster structure of territories – automated information systems, which makes it possible to monitor clusters constantly and systematically and thus correct cluster industrial policy. Methodological tools were developed and tested to model the evaluation of the impact produced by industrial clusters on the economy of regions based on the methods of econometric analysis.

The practical contributions of the research are as follows:

1. Using computations and the database “Clusters of Russia’s Regions” the cluster structure of the Russian regions and its dynamics were determined; the localisation regions of cluster cores in the period from 2008 to 2016 were identified; and the industrial clusters that determine positive externalities for the economy of Russia’s regions in the period from 2008 to 2016 were highlighted.

2. The dynamics of the sectoral cluster structure in St. Petersburg were assessed, cluster maps were drawn and analysed to find out about related meta-cluster groups, and the content characteristics of the region’s cluster structure were presented.

3. Explicitly descending and ascending forms of cluster promotion and an implicitly descending form of cluster promotion in St. Petersburg were determined, which allowed

us to implement a differentiated approach to framing cluster industrial policy. Measures of St. Petersburg cluster industrial policy were substantiated in detail by all groups of the region's clusters.

Research limitations and further research

The research study used the classification of clusters proposed by Porter. The application of the classification proposed by M. Porter has essential limitations since interrelations of enterprises are considered to be set within sectoral and inter-sectoral cooperation and integration, which can be inconsistent with the sectoral structure of Russia. To solve this problem, research should be conducted to determine and systematise the microstructure of clusters in Russia, while the activity of individual enterprises localised in the territory should also be studied. In addition, types of economic activities, which should be considered as part of one cluster for Russia specifically, should be determined based on the analysis of input-output matrixes.

The research study was tested on the example of Russia, and includes the methodology of assessing the impact of industrial clusters on the economy of a region and the developed database. However, the suggested methodology is flexible and can also be applied to evaluate the impact of industrial clusters on other economic indicators of a region and for other regions (countries).

Further, the methodology proposed by the European Cluster Observatory can be supplemented and transformed so that it can be used to evaluate other indicators of cluster development. It is also planned to expand the functionality of the devised database to provide convenient input and editing of information about the employed population of regions, and introduce automated reports that reflect the dynamics of cluster development in the Russian regions. Moreover, the obtained results can be used to build spatial econometric models aimed at measuring spatial externalities for various clusters.

One more direction for further research is studying the mechanisms of knowledge spillovers and assessing the impact of government policy on cluster development at the micro level.

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Abstract
Cluster industrial policy and tools in the transition economy: The case of Russia

Effective cluster industrial policy is a priority for countries that aim to achieve economic growth, but it has certain limitations and problems of introduction at developing countries. According to institutional theory, one of the key factors is the social interaction between industrial subjects, which is realised in the framework of cluster interactions. Therefore, the current development stage of industrial policy is closely related to cluster policy. Its effective implementation depends on the interaction between state, business, and institutions of civil society. However, this interaction can be well established and regulated in developed economies, but for transition economies, it can be different. The main problem is about transition, given that forms and means of interaction between state, business, and civil society are changing, and all of them are trying to reach a new equilibrium state. Transition economies can also be characterised by the following specifics: a lower level of integration in global value chains, political factors, disruption of the established production chains, resource dependence, and instability of the economy. Therefore, it is essential to discuss cluster development and cluster industrial policy development in transition economies. The given task is particularly relevant to Russia in terms of long-term reformation and institutional transformations undertaken within the last 30 years. Therefore, the research aim was to determine principles, methods, and instruments for formation of the cluster industrial policy targeted at enhancing competitiveness and growing localisation of cluster enterprises in a territory to achieve the effect of clustering – welfare growth of the transition economy using Russia as an example.

The main tool of implementing the cluster industrial policy was a study on cluster structures at the micro- and macro-levels, that is, the cluster structure of a territory and the structure of an industrial cluster. The tool set included studying the industrial features of clusters, analysing their territory localisation, and evaluating the effect of the cluster structure on territorial economies. To automate the analysis of cluster localisation territories, I created a database called “Clusters of Russia’s Regions” (state registration certificate RIA No.2017620569 of May 29, 2017). The database was designed to determine the regions of cluster localisation using data on the population employed in various types of activity. The influence of the cluster structure on the economy was measured on the basis of econometric modelling.

By testing the developed tools, the cluster structure was defined for 83 regions of the Russian Federation, and localisation maps were built for 37 clusters in Russia’s territory during the period from 2008 to 2016. Then, the assessment of the localisation effect of 37 clusters in the Russian territory on the GRP was conducted. As a result, we identified a list of clusters – “Automotive Industry”, “Analytical Tools”, “Aerospace Engineering”, “Biopharmaceuticals”, “Information Technology”, “Metallurgical Industry”, “Plastics”, “Production Equipment” and “Chemical Industry” – which had a positive impact on the size of GRP in the long run.

Consequently, I conducted a detailed analysis of one of the Russian regions – St. Petersburg. The analysis evaluated the dynamics of the industry-specific cluster structure of St. Petersburg for the period 2008–2016, identified the factors limiting the development of industrial clusters, defined the institutional forms for promoting St. Petersburg’s clusters, and substantiated the action items of St. Petersburg’s cluster

industrial policy. As a result, it was possible to draw a conclusion about a fairly well-developed cluster structure in St. Petersburg. In the period of 2008–2016, St. Petersburg showed intense development of a meta-cluster group that could be specified as innovative due to the concentration of high-tech production facilities in the field of instrument engineering and power engineering. The research findings resulted in recommended directions and guidelines for measures of St. Petersburg state cluster policy.

Next, I generalised theory on clusters in transition economies, the approaches for cluster development and formation, results of the empirical analysis and came up with the mechanism of cluster industrial policy. The mechanism includes the goals, principles, tools, and components of the cluster industrial policy. It is based on the following framework elements: priority cluster directions of an industrial country, actions, and tools of the cluster industrial policy. Reciprocity of all elements of the mechanism of the cluster industrial policy brings about a positive synergy effect, which is expressed in Marshall's externalities from the interaction of enterprises in a cluster and ensures the growing wealth of the population in the territory. Priority directions for the clustering industry are determined based on the studied cluster macro-structure of a territory, including the analysed localisation level of enterprises of a cluster in the territory and their comparative advantages. Regional cluster industrial policy is framed based on the research of coherence, effectiveness, and resource availability of clusters in a region, and the institutionalisation of the promotion forms of clusters in the region. The tools of the cluster industrial policy are determined by analysing the integrity of the structure of an industrial cluster, as well as the coherence, efficiency, and resilience of enterprises of the industrial cluster.

Further, based on the conducted analysis, I augmented the approach for classification of clusters, initially presented by Martina Fromhold-Eisebith and Gunter Eisebith. This approach was developed through the introduction of the second categorisation dimension, differentiating explicit and implicit cluster promotion based on institutional prerequisites. It is graphically presented as a transformation process of cluster promotion forms and their conversion into state cluster policy. The transformation process can start with private industrial initiatives, which can then be supported by local government bodies, and as a result, the implicitly ascending promotion form of industrial enterprises will convert to an implicitly descending promotion form. Or private industrial initiatives started at the local level will be supported by private industrial elites on the regional or federal level, and, thus, the implicitly ascending promotion form of industrial enterprises will turn into an explicitly ascending promotion form. Finally, supported either by local government bodies or by industrial associations at the regional level, cluster promotion will have the form of state industrial policy, which can be classified as an explicitly descending form of cluster promotion.

In accordance with the developed mechanism and augmented approach for cluster classification, the priority directions of clustering territorial economies and the development and validation of measures and tools of the state cluster policy in transition economies can be identified.

Lühikokkuvõte
Klastri tööstuspoliitika ja üleminekumajanduse vahendid: Venemaa näide

Tõhus klastri tööstuspoliitika on prioriteet riikides, mille eesmärk on saavutada majanduskasv, kuid selle sissetoomisel arengumaadesse on teatud piirangud ja probleemid. Institutsionaalse teooria kohaselt on üks peamisi tegureid tööstuslike subjektide sotsiaalne koostoime, mida viiakse täide klastrite koostoimete raames. Seetõttu on tööstuspoliitika praegune arenguetapp tihedalt seotud klastripoliitikaga. Selle tõhus rakendamine sõltub riigi, ettevõtjate ja kodanikuühiskonna institutsioonide vastastikusest mõjust. Selline koostoime võib arenenud riikides olla hästi juurdunud ja reguleeritud, kuid erinev üleminekumajanduste puhul. Peamine probleem on üleminek, mis tähendab, et riigi, ettevõtete ja kodanikuühiskonna vahelise suhtluse vormid ja vahendid muutuvad ning kõik püüavad jõuda uude tasakaaluolekusse. Lisaks võivad üleminekumajandusi iseloomustada järgmised eripärad: madalam lõimumine ülemaailmsete väärtusahelatega, poliitilised tegurid, väljakujunenud tootmisahelate katkemine, ressursisõltuvus ja majanduse ebastabiilsus. Seetõttu on oluline arutada klastriarendust ja klastri tööstuspoliitika arendamist üleminekumajandustes. Antud ülesanne on Venemaa jaoks eriti oluline pikaajalise reformatsiooni ja institutsiooniliste muutuste tingimustes, mis on viidud läbi 30. aasta jooksul. Teadusuuringute lünga täitmiseks tuleb määrata kindlaks tööstuse klastripoliitika moodustamise põhimõtted, meetodid ja vahendid, mille eesmärk on suurendada konkurentsivõimet ja klastriettevõtete kasvavat lokaliseerimist territooriumil saavutamaks klastrite loomise mõju – üleminekumajanduse heaolu kasv Venemaa näitel.

Klastri tööstuspoliitika rakendamise peamine tööriist on klastri struktuuri uurimine mikro- ja makrotasandil, s.o. piirkonna klastristruktuur ja tööstusliku klastri struktuur. Instrumentaarium sisaldab klastrite tööstusspetsiifiliste tunnuste uurimist, nende lokaliseerimise piirkonna analüüsi ja klastristruktuuri mõju hindamist piirkonna majandusele. Klastrite lokaliseerimisalade analüüsi automatiseerimiseks loodi klastrite lokaliseerimise piirkondade kindlaksmääramiseks andmebaas “Vene regioonide klastrid” (RIDi riikliku registreerimise tunnistus nr 2017620569, 29. mai 2017). Kujundatud andmebaas on loodud klastrite lokaliseerimise piirkondade kindlaksmääramiseks vastavalt elanikkonna tööhõive andmetele erinevat tüüpi tegevustes. Klastristruktuuri mõju majandusele hinnati ökonomeetrilise modelleerimise põhjal.

Arendatud tööriistade testimise osana määrati kindlaks Vene Föderatsiooni 83 piirkonna klastristruktuur ja konstrueeriti aastatel 2008-2016 Vene Föderatsiooni territooriumi 37 klastri lokaliseerimise kaardistus. Järgmisena hinnatakse Venemaa 37 klastri lokaliseerimise mõju regionaalsele kogutoodangule. Selle tulemusel määratletakse kogutoodangule pikas perspektiivis positiivse mõjuga klastrite loetelu: „Autotööstus“, „Analüütilised instrumendid“, „Aerokosmose tehnika“, „Biofarmaatsia“, „Infotehnoloogia“, „Metallurgiatööstus“, „Plastikud“, „Tootmisseadmed“ ja „Keemiatööstus“.

Sellest tulenevalt analüüsisin üksikasjalikult ühte Venemaa piirkonda – Peterburi. Analüüsis hindasin Peterburi tööstusspetsiifilise klastristruktuuri dünaamikat aastatel 2008–2016, tegin kindlaks tööstusklastrite arengut piiravad tegurid; määratlesin Peterburi klastrite edendamise institutsionaalsed vormid ja põhjendasin Peterburi klastri tööstuspoliitika meetmeid. Selle tulemusena oli võimalik teha järeldus Peterburi üsna hästi arenenud klastristruktuuri kohta. Aastatel 2008–2016 näitas Peterburi metaklastri

rühma intensiivset arengut, mida võiks pidada uuenduslikuks tänu kõrgtehnoloogiliste tootmisrajatiste koondumisele aparaadiehituse ja elektroenergeetika valdkonnas. Uuringu tulemusena koostati Peterburi riikliku klastripoliitika meetmete soovituslikud juhised ja suunised.

Järgmisena üldistasin teooriat üleminekumajanduse klastrite kohta, klastrite arendamise ja moodustamise lähenemisviise, empiirilise analüüsi tulemusi ja tõin välja klastri tööstuspoliitika mehhanismid

Mehhanismid hõlmavad klastri tööstuspoliitika eesmärke, põhimõtteid, vahendeid ja osi. See põhineb järgmistel raamelementidel: tööstusriigi prioriteetsed klastrisuunad, klastri tööstuspoliitika meetmed ja vahendid. Klastri tööstuspoliitika mehhanismi kõigi elementide vastastikkus toob kaasa positiivse sünergia, mida väljendatakse Marshalli välismõjudes klastri ettevõtete omavahelisest suhtlusest ja mis tagab piirkonna elanikkonna kasvava jõukuse. Klastri tööstuspoliitika prioriteetsed suunad määratakse kindlaks territooriumi uuritud klastri makrostruktuuri põhjal, sealhulgas piirkonna klastri ettevõtete analüüsitud lokaliseerimise taseme ja nende suhteliste eeliste põhjal. Piirkondliku klastri tööstuspoliitika kujundamisel lähtutakse piirkonna klastrite sidususe, tõhususe ja ressursside kättesaadavuse uuringutest ning piirkonna klastrite edendusvormide institutsionaliseerimisest. Klastri tööstuspoliitika vahendid määratakse kindlaks tööstusklastri struktuuri terviklikkuse ning tööstusklastri ettevõtete sidususe, tõhususe ja vastupidavuse analüüsimisega.

Samuti laiendasin läbiviidud analüüsi põhjal klastrite klassifitseerimise lähenemist, mille algselt esitasid Martina Fromhold-Eisebith ja Gunter Eisebith. See lähenemisviis töötati välja teise kategoriseerimise mõõtme kasutuselevõtmise kaudu, eristades klastrite otsest ja kaudset edendamist, ka tänu institutsioonilistele eeltingimustele. See on graafiliselt esitatud klastri edendamise vormide ümberkujundamisprotsessina ja nende muutmisena riiklikuks klastripoliitikaks. Ümberkujundamisprotsess võib alata eraõiguslike tööstusalgatustega, mida saavad seejärel toetada kohalike omavalitsuste organid, ning selle tulemusena muutub tööstusettevõtete kaudselt tõusev edendusvorm kaudselt kahanevaks edendusvormiks. Või kohalikul tasandil alustatud erasektori tööstusalgatusi toetavad eraõiguslikud tööstuseliidrid piirkondlikul või föderaalsel tasandil ning seega muutub tööstusettevõtete kaudselt tõusev edendamine otseselt tõusvaks edendamiseks. Olenemata, kas kohalikud omavalitsused või tööstusühendused toetavad piirkondlikul tasandil klastrite edendamist, saab sellest riikliku tööstuspoliitika vorm, mida võib liigitada klastrite edendamise otsese kahaneva vormina.

Vastavalt välja töötatud mehhanismile võivad pakutud vahendid olla suuniseks piirkonna majanduse klastrimiseks prioriteetsete valdkondade kindlaksmääramisel, riikliku tööstusklastripoliitika meetmete ja instrumentide väljatöötamisel ja põhjendamisel; investeeringud, mille eesmärk on stimuleerida piirkondliku majanduse uuenduslikku arengut; klastrite infrastruktuuri loomine, klastritegevuste seadusandliku ja teabetoetuse süsteem.

Appendix 1

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Identification and Analysis of the Cluster Structure of a Territory and its Impact on Regional Development: An example of Russia

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Abstract:

Identification, development, and management of the cluster structure of territories is an important factor of economic growth. The purpose of this study is to determine the cluster structure of Russian regions and assess the impact of these cluster specialization on the size of gross regional product (GRP). For this purpose, the methodology of the European Cluster Observatory was used and the following indicators were calculated: 'Location quotient', 'Cluster size', and 'Cluster focus' for 37 clusters in 83 regions of the Russian Federation within the period from 2009 to 2018. The calculation was performed using the developed automated database 'Clusters of Russian regions'.

Based on the results obtained, the cluster specialization was determined and hypotheses were tested on the presence of positive externalities, i.e. on the existence of a positive correlation between the cluster specialization of regions and the size of their GRP from 2011 to 2015. Thus, the authors conclude that the increased specialization of Russian regions lled to positive agglomeration effects - externalities. The proposed toolkit can serve as a reference for the development and justification of the state industrial cluster policy.

Keywords: cluster structure of regions; location quotient; gross regional product; agglomeration externalities.

JEL Classification: O40; R11; C38.

Introduction

Creation and development of clusters allows unlocking the potential of the region and strengthening its competitiveness (Porter 2001, Ketels and Memedovic 2008). Characteristics such as the size, level of localization, and focus of clusters determine the volume and the quality of knowledge that circulates between enterprises and organizations of clusters under study (Lindqvist 2009). As a consequence, development of clusters should lead to the emergence of synergetic effects that have a positive impact on the growth of the region's economy (Zemtsov *et al.* 2017; Rudskaya and Rodionov 2017; Schepinin 2018) and on strengthening its innovative potential (Lebedev *et al.* 2018, Kozlov *et al.* 2017). However, regardless of the type of a cluster, the question of assessing the impact of cluster specialization on the economy of the region remains open and subjective to different

interpretations (Beaudry and Schiffauerova 2009; Peiró-Signes *et al.* 2015; Falcioğlu, Akgüngör 2008; Morrissey 2016).

The goal of the study therefore is to determine the cluster regional structure of Russia and to assess its impact on the regional development factor - gross regional product (GRP).

In this paper, the authors follow the top-down approach to cluster identification. This approach assumes that on the basis of macroeconomic data on the structure of employment in the region, it is possible to determine the 'critical mass' of the cluster core and form 'benchmark clusters'. Compliance of a particular cluster with the benchmark determines its relative strength and competitiveness. Besides, the more developed the cluster specialization of the region is, the more positive externalities are generated within it (Lindqvist 2009; Protsiv 2016; Sölvell *et al.* 2003).

In this study, the cluster structure of the territory is understood as an agglomeration, which includes industrial, infrastructural, and raw material clusters localized in the territory and interconnected within the framework of vertical and horizontal integration. The territorial structure of Russia has a regional division and consists of 85 Federation subjects. The rest of the work is organized in the following manner: the next sections gives the background on clusters and agglomeration effect. It also explains in details different methodologies common in cluster identification. The third section elucidates the methods used for this work followed by the results and discussion. The last section concludes.

1. Research Background

1.1. Clusters and Agglomeration Effects

The theoretical basis of the study in this paper is the cluster theory put forward by Porter (2001, 1998); Delgado *et al.*2014); and further developed by the European Cluster Observatory (Lindqvist 2009; Sölvell *et al.* 2003; Ketels and Protsiv 2014). According to Porter, M. a cluster is 'a group of geographically neighboring interrelated companies and related organizations operating in a particular field, characterized by commonality of activities and mutually supplementing each other' (Porter1998). As a result of establishing specific forms of spatial concentration of enterprises, i.e. clusters, agglomeration externalities usually emerge in the regional economy (Paci and Usai 2008; Bishop and Gripaios 2010). In the early 20thcentury, agglomeration externalities, which are expressed in the economy from co-localization and geographical concentration of companies in certain areas were considered as an integral element of competitiveness within the framework of economic geography and the theory of competitiveness (Hallet 2002).

Thus, Marshall (1920) developed the idea that spatial concentration of companies belonging to the same industries may become a source for developing such agglomeration effects (external savings). In other words, according to Marshall, the specialization of the economy of a certain territory is directly related to the creation of innovations in its industries (Marshall1890). Thus, the easier and faster it is to exchange knowledge and resources on the territory of an agglomeration, the more fruitful it becomes for creation and development of innovations (Ahlfeldt and Feddersen 2018).

On the other hand, Jacobs (1969) took the position that it was not the industries, activities, or interrelationships that were important, but the spatial concentration of the economic activity noticeable in that given area. In her opinion, development of new types of business, products, and technologies is conditioned by proximity of enterprises belonging to different types of the economic activity, as a result of the application and adaptation of ideas used in them. As a consequence, the central idea of Jacobs' research is the need to strengthen the positive agglomeration effects and, consequently, the innovative potential of enterprises by providing conditions for diversification of the economy in any territory (Content and Frenken 2016; Liang and Goetz 2018).

Therefore, from Jacobs' point of view, co-localization of enterprises of different industries is the major source of positive agglomeration effects which contradicts Marshalls summation that auxiliary clusters are not integral part of the agglomeration, but only 'surround' it, as the effect of joint placement of enterprises that make up an industrial agglomeration. (Zhu *et al.* 2017; Suedekum and Blien 2005; Caragliu *et al.* 2016).

Reasoning out these aspects shows that M. Porter's cluster theory combines the main ideas proposed by A. Marshall and J. Jacobs. Hence, the concept of the cluster involves consideration of enterprises that operate in inter-complementary and interrelated industries, combining the Marshall effects of geographical concentration of enterprises in the same industry and agglomeration externalities of Jacobs that focuses on the results of the co-localization of enterprises with different types of activities in a certain area. This way, the links between enterprises are understood as both vertical value chains and horizontal links that emerges from the exchange between inter-complementary technologies, products, services, specialized factors of production (Porter 2001; Sahdev 2016) and

further implying that the main difference between cluster formations and other agglomeration forms is their inter-sectoral nature.

As established, agglomeration externalities (proximity effects) and spatial concentration (agglomeration) have a certain influence on each other but exist separately. Therefore, the increasing attractiveness of territories for business maybe due to the development of agglomeration effects, which leads to an increase in the geographical concentration of enterprises. On the other hand, more efficient use of the existing skills and development of new ones, along with increased labor force mobility, are also the result of the increased geographical concentration that leads to localization and enhanced agglomeration effects (Peiró-Signes *et al.* 2015).

In the framework of the research, the authors take the position that implies that it is difficult to determine the nature of the origin of externalities, as well as to identify and measure separately the effects of A. Marshall and J. Jacobs. This approach was successfully used by Lindqvist (2009) to study the cluster structure of the Swedish economy. Along this line, the paper will attempt to determine the presence or absence of the influence of cluster specialization and diversification of the regions on indicators such as the GRP (gross regional product) of regions, without identifying the nature of the externalities.

1.2. Approaches to Cluster Identification

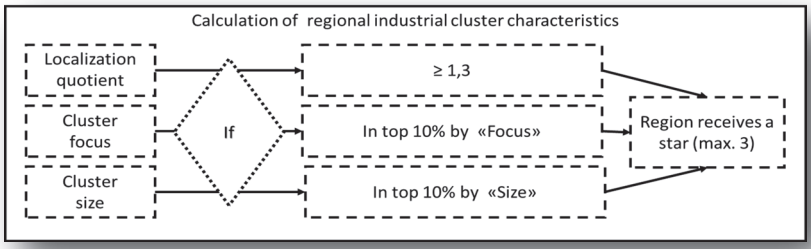
A key issue in the cluster theory may be the problem of identifying clusters in regions (individual territories) (Brachert *et al.* 2011; Taranova *et al.* 2015; Heuvel *et al.* 2010). Based on the analysis of foreign experience, we can highlight a number of methodological approaches to identifying clusters, but the main challenge is that there are still significant differences in application of tools in practice when you take into account the existing information and analytical base. Within the framework of the first approach - 'bottom-up' - identification of clusters takes place based on previously known information that emphasizes that enterprises and industry leaders are located in a certain territory (Porter *et al.* 2011; Boix *et al.* 2015). The second approach - 'top-down' - searches for spatial localization of clusters is based on statistical data on specific and interrelated activities in the area. Besides, national samples or benchmark clusters are used to identify specific regional clusters.

Correspondingly, within the framework of the top-down approach to cluster identification, this work uses two main and constant properties of clusters, namely, functional connectivity and geographical proximity.

To achieve the best results of cluster identification using the top-down approach, it is necessary to use a combination of methodologies that focus on identifying both functional and spatial relationships. This approach is implemented in the methodology developed by M. Porter (2001), Delgado *et al.* (2014, 2015) where Porter defined the structure of 'benchmark' clusters in the American economy on the basis of a detailed analysis of activities included in the American classifier SIC (Standard Industrial Classification). This method has become classical and is used in many countries especially in Europe where many countries have used this approach or its modifications to identify their regional clusters.

Furthermore, the US Department of Commerce used the results obtained by Porter to map US clusters based on the 'benchmark' cores of the cluster groups he had identified (Harvard Business School 2018). These results were used in the development and implementation of the European Cluster Observatory project aimed at analyzing and mapping clusters of the EU countries (Protsiv 2016). In this project, the composition of Porter's 'benchmark' clusters was adapted to the specifics of the EU economy on the basis of data from the European classifier NACE (Sölvell *et al.* 2003). In the Russian Federation, such adaptation based on the NACE classifier has not been fully carried out. As a rule, in the framework of national studies in Russia, either separate clusters or cluster initiatives are considered (Islankina *et al.* 2017, Uskova *et al.* 2010, Kutsenko, 2015), and most times only formal clusters, created and supported by the state (National Research University Higher School of Economics 2019). The cluster structure and the identification of latent clusters have been practically ignored (Shchepakin and Zhukova2013, Kiseleva and Chunina 2018).

The context of the cluster identification method is the assumption that the volume and quality of knowledge circulating between enterprises and organizations included in a cluster under study depends on the size of the cluster and the level of its specialization. The European Cluster Observatory defined these factors as 'Location quotient', 'Size' of the cluster and 'Focus' of the cluster region (Lindqvist2009). Values of the factors within certain thresholds reflect whether the studied cluster has reached sufficient 'critical mass' to generate positive external effects and relationships. These values are calculated using employment statistics (see Figure 1).



Source: Developed by authors.

Figure 1. Methodology for identification of cluster localization area

Lindqvist (2009) proposes to use a value higher than 2 for the location quotient and a mark of 10% for 'Size' and 'Focus' meaning the region should be in the first 10% on the values of the parameter's 'size' or 'focus'. If the values of the region are higher than the limit values, the region can get a 'star'. Each region can get maximum 3 stars for each cluster. The more stars there is, the greater the power of the cluster in the region (see Figure 1). Apart from this, a star cannot be assigned to a cluster in a region if the number of employees in that cluster does not exceed 1000 people. The sum of stars in all clusters of regions will determine the level of their specialization. Thus, application of this methodology will allow the determination the number of clusters and the level of relative specialization of such regions.

1.3. Location Quotient (LQ) as a Measure of Concentration and Specialization

LQ is one of the most frequently used statistical parameters for identification of a cluster in the given territory and assessment of the level of specialization of the region in the activities under study (9). It is often used as the only measure that determines the specialization of a region by a particular activity. In this regard, scientific literature widely considers the question of what value of 'location quotient' is sufficient and necessary to identify a cluster in a given territory. For example, 1 (Bishop *et al.* 2003); 1.25 (Feser and Bergman 2000); 1.3 (Braunerhjelm and Carlsson1999); 2 (Lindqvist 2009); and 3 (Isaksen1996) are allocated as boundary values of LQ. Scientists continue to use an arbitrary boundary LQ value as a uniform measure in all studies, ignoring the fact that it is impossible to determine one correct LQ value that will be true for all cases (Peiró-Signes *et al.* 2015).

To overcome the need to determine the LQ boundary value randomly, O'Donoghue and Gleave (2004) suggest using the standardized LQ (SLQ) value to identify clusters in the regions where the concentration of certain clusters is extremely high. The SLQ value should be higher than 1.96 for a two-way test and 1.65 for a one-way test. Peiró-Signes *et al.* (2015) and others developed this idea and proposed classification of the cluster concentration force based on SLQ values. So, if the SLQ value is between 1.25 and 1.96, it is considered as a 'low concentrated cluster', if between 1.96 and 3, it is a 'medium concentrated cluster', and if the SLQ is above 3, it is a 'highly concentrated cluster'. The main limitation in using SLQ is that LQ values must be normally distributed, which depends directly on how the initial employment data are aggregated by a region and a sector of the economy. Within this study, the authors take the position that the threshold value should be set at 1.3. This is because a lower threshold value, compared to the one used by the European Cluster Observatory, is more suitable for the specific domestic conditions because of the available databased. For example, statistics on the number of employed people do not take into account self-employed people, referring a large share of the employed to large and medium-sized enterprises, which results in the presence of high employment in individual clusters without high competition.

Accordingly, the adaptation of the results of the study of M. Porter's 'benchmark' clusters will be used for study using the Russian Classifier of Economic Activities (OKVED) to determine the 'benchmark' clusters characteristic of the Russian Federation. The criteria and methods proposed by the European Cluster Observatory will be used to determine the relative strength of clusters identified, *i.e.* the extent each cluster is localized in a particular region. Consequently, the cluster structure of Russian regions and the level of sectoral specialization of regions will be determined. Additionally, to determine the importance of agglomeration effects in the study, the impact of localization of clusters of a region on the gross regional product is estimated. This is relevant for the study of the cluster structure in the Russian Federation, as scientific literature, which that calculates the cluster specialization of Russian regions and assess its impact on the size of the gross regional product is still visibly lacking.

2. Research Methodology

2.1. Cluster Identification

To identify and analyze the cluster structure in the territory of Russia, statistics between 2009 and 2018 on the number of employees were grouped according to the cores of clusters designed by M. Porter. To implement this approach, it was essential to correlate the codes of the European Classifier NACE, used by the European Cluster Observatory for cluster identification, and Russian OKVED. Because of this adaptation, a list of economic activities by OKVED were identified, showing a detailed core 37 clusters. The study takes these as cluster benchmarks. To determine the regions of cluster localization for the purpose of automating calculations when processing large data, the database 'Clusters of Russian regions' was developed, which has a state certificate RID No. 2017620569 dated May 29, 2017 (Babkin *et al.* 2017).

2.2. Modeling and Hypothesis Formulation

To analyze the impact of the cluster structure in territories on the economy of the region, econometric modeling was conducted in the program STATA MP14. As a result, the connection between cluster specialization parameters and the gross regional product size was assessed. The task was solved in two stages. At the first stage, the interconnection between the fact of clusters presence in the region and the GRP level was assessed. At the second stage, the interrelation between the level of cluster structure development and the GRP size was assessed, i.e. the value of multiplicative effect of cluster localization in the region or quantitative assessment of externalities generated by regional specialization.

At the first stage, hypotheses were tested on the existence of a correlation between the presence of cluster j in region i and its GRP size at different time, namely, in the current and previous periods. The impact of cluster specialization in 2011, when the Russian economy began to recover from the global financial crisis of 2008-2009, is considered separately.

Thus, *hypothesis 1*is given**:** *the presence of a cluster in a region causes a larger economy not only in a particular year, but also in the long term*.

If a certain set of activities has a sufficient critical mass in a region at the beginning of the period under consideration, then subsequently, GDP in that region will be higher than in regions where its 'critical mass' is insufficient.

The following models were developed to test these hypotheses:

$$\ln\mathrm{GRP}_{\mathrm{it}} = \beta_0 + \beta_{\mathrm{i}}\mathrm{Cluster}_{jit} + \varepsilon_{\mathrm{jit}} \quad (1)$$

$$\ln\mathrm{GRP}_{\mathrm{it}} = \beta_0 + \beta_{\mathrm{i}}\mathrm{Cluster}_{\mathrm{jit}-1} + \varepsilon_{jit} \quad (2)$$

$$\ln\mathrm{GRP}_{\mathrm{it}} = \beta_0 + \beta_{\mathrm{i}}\mathrm{Cluster}_{jit=2011} + \varepsilon_{\mathrm{jit}} \quad (3)$$

where $\ln\mathrm{GRP}_{\mathrm{it}}$ is a natural logarithm of the GRP size (RUB, in constant prices of 2011) generated in region *i* at moment *t*;$\mathrm{Cluster}_{jit}$ is a binary variable taking value 1 if cluster *j* is localized in region *i* at moment *t*, and 0 if not.;$\mathrm{Cluster}_{\mathrm{jit}-1}$ is a binary variable taking the value of 1 if cluster *j* was detected in region *i* at moment *t-1*, and 0 if not.$\mathrm{Cluster}_{\mathrm{jit}=2011}$ is a binary variable taking the value of 1 if cluster *j* was detected in region *i* in 2011, and 0 if not.$\varepsilon_{\mathrm{jit}}$, is a random value characterizing the deviation of the real value of the resultant feature from the value of the regression equation;β_0 is a constant value.

At the second stage, according to the model proposed by Lindqvist, the analysis of the influence of the cluster structure in the region on the GRP size is carried out.

Thus, *hypotheses 2*is given: *there exist an interrelation between the level of cluster structure development in region i and on the GRP size at different points of time*.

In this case, the hypothesis of a correlation between the general level of regional specialization and the GRP size was tested. It was also implied that this relationship is also significant in time. This means that if at the beginning of the period a region had a high level of specialization (it has a large number of clusters with a sufficient volume of 'critical mass'), then in the future its volumes of the economy will be on average higher than those of regions with a lower level of specialization. The models used for testing hypothesis 2 are as follows:

$$\ln\mathrm{GRP}_{\mathrm{it}} = \beta_0 + \beta_{\mathrm{i}}Dev\_of\_cluster_{it} + \varepsilon_{\mathrm{it}} \quad (4)$$

$$\ln GRP_{it} = \beta_0 + \beta_i Dev\_of\_cluster_{it=2011} + \varepsilon_{it} \quad (5)$$

$$\ln GRP_{it} = \beta_0 + \beta_i Dev\_of\_cluster_{it-1} + \varepsilon_{it} \quad (6)$$

where $Dev\_of\_cluster_{it}$ is a variable reflecting the general development level of the cluster structure of the economy of region *i* at moment *t*. That is the level of specialization of the region. This variable is calculated by adding the 'stars' obtained by all cluster groups *j* in the given region at moment *t* according to the results of evaluation of 'location quotient', 'cluster size', and 'cluster focus'. According to Lindqvist, this approach allows reflecting the level of specialization of the region and development of the cluster structure in it.$Dev\_of\_cluster_{it-1}$ is a variable reflecting the general development level of the cluster structure of the economy of region *i* at moment *t-1*.$Dev\_of\_cluster_{it=2011}$ is a variable reflecting the general development level of the cluster structure of the economy in region *i* in 2011.

3. Results and Discussion

Database of the cluster structure of 83 Russian regions and build localization charts for 37 clusters in the territory of the Russian Federation from 2009 to 2018 was determined using the employment data posted in the Unified Interdepartmental Statistical Information System (EMISS) (Federal Statistical Service 2017, 2019). Data from 2011 to 2015 were used for the econometric analysis. This is because since 2016, the OKVED codes in Russia has changed, which has had a negative impact on the structure of data for a number of clusters.

3.1. Localization Analysis on the Example of Biopharmaceutical Cluster of the Russian Federation

To test whether the presence of a cluster in a region causes a larger economy not only in a particular year, but also in the long term, a case of the results on Biopharmaceuticals one of the 37 clusters examined is used. The structure of the Biopharmaceuticals cluster includes two main activities in accordance with OKVED '22.4 - Manufacturing of pharmaceutical products' and '22.5 - Production of soap; detergents, cleaners, and polishers; perfumes and cosmetics.'

From the results of the study on the regions (appendix1) where there is a sufficient concentration of workers in the biopharmaceutical cluster according to the methodology, diagrammatic maps were drawn (see Figure 2 and Figure 3) and regions of the Biopharmaceutical cluster localization in Russia were identified. From this figure, Biopharmaceuticals cluster is localized in 2018 in the following regions: Moscow, Moscow region, Tula, Kursk, and Kaluga regions; St. Petersburg; Kurgan region; Novosibirsk region. Showing that the cluster is mainly located in the Central Federal District. Here, the largest cluster size is achieved mainly in Moscow - 15.49%, in the Moscow Region - 15.44%. The largest localization is achieved in the Kurgan region - 4.67%. The leading subject of the Russian Federation in terms of the number of employees in the cluster group industries is Moscow (18120 people) and the Moscow region (18070 people), where such large enterprises for the production of medicines as chemical-pharmaceutical plant JSC 'Akrikhin', JSC 'Valenta Pharmaceutical', LLC 'KRKA-RUS', 'Biokad' and others are located. The largest value of the location quotient is inherent to the cluster group of the Kurgan region, which indicates that the number of employees of the Kurgan region in the cluster of Biopharmaceuticals is several times higher than the uniform distribution of workers in accordance with their total number.

Source: Developed by the authors

Figure 2. Diagrammatic maps of specialization of Russian regions between 2009: biopharmaceutical cluster

Source: Developed by the authors.

Figure 3. Diagrammatic maps of specialization of Russian regions between 2018: biopharmaceutical cluster

The reason for this is not farfetched. The region is home to the largest enterprise of the domestic pharmaceutical industry, JSC 'Sintez', which provides about 3% of the Russian medicines. More so, Saint Petersburg ranks third in the number of employees working in the branches of the Biopharmaceutical cluster, behind Moscow and the Moscow region. In the territory of the region, there is a number of enterprises of the corresponding branches: LLC 'Novartis Neva', LLC 'Geropharm', JSC 'Pharmasintez', LLC 'Immuno-Gem'. A distinctive feature of biopharmaceutical enterprises in St. Petersburg is a developed structure of scientific and practical departments responsible for the development of new drugs. In addition, in 2010, a pharmaceutical cluster of St. Petersburg was created, later expanded to a cluster of Pharmaceutical and Medical Industry, designed to promote creation, production, and introduction of innovative drugs, reproduced drugs, and medical equipment, and as part of the Special Economic Zone, biomedical enterprises, including the pharmaceutical cluster, are granted tax and customs benefits. This result suggest that localization of the Biopharmaceuticals cluster is gradually strengthening around individual regions and unified territorial inter-regional cluster groups are being formed.

This confirms the application of the developed database allows analyzing regions of clusters localization in the territory of Russia and evaluating the dynamics of localization. The results of the analysis can become the basis for assessing effectiveness of federal and regional programs of cluster development.

The advantage of the developed database is that relying on the results of its application; it is possible to create diagrammatic maps of concentration and localization of clusters in regions of the Russian Federation (level NUTS-2). Generally, this project is a direct analogue of a joint project of Harvard Business School and the US Department of Economic Development (Harvard Business School 2018) – US cluster mapping – and the EU Commission project – European observatory for clusters and industrial change (Protsiv 2016). Implementation of this database in the Russian Federation will allow managing the development of territories and the determination of the places of concentration for clusters formed by the state and for latent i.e. implicit clusters, which emerge from the interaction of factors of the first and the second nature.

The level of details for the social and economic data collected by the official state statistics services meets the levels from NUTS - 0 (country level) to NUTS - 2 (level of federation subjects). Unfortunately, the level of detail NUTS – 3 (level of cities and districts) for the used data is not available. In this respect, relevant EU and US projects can provide more detailed and accurate information about the places of concentration of the activities under study.

3.2. Econometric Modeling

Next, the hypothesis on the correlation between regional cluster localization in 2011 and the GRP in 2011-2015 is tested. In this case, it is assumed that the presence of cluster j in region i in the base year (2011) has a continuous effect on the GRP in Russian regions in subsequent years (2011 – 2015).

According to the results (appendix 2), there is a significant positive correlation between the presence of 17 out of 19 industrial clusters in the region and the GRP. This correlation is maintained for all 17 clusters during the test of the second group of hypotheses, which suggests a positive short-term effect of the cluster's presence in the region at time $t-1$ on the GRP at time t. However, the long-term five-year effect is observed only in 10 cases. Thus, only the presence of

such clusters as Automotive Industry, Analytical Tools, Aerospace Engineering, Biopharmaceutics, Information Technology, Steel Industry, Plastics, construction, Production Equipment, and Chemical Industry in 2011 has had a positive effect on the GRP within 2011-2015. The effect of such clusters as Medical Instruments, Shoes, Lighting and Electric Equipment, Textile, and Heavy Engineering is insignificant in the long run. This result may indicate a lack of an obvious correlation between the presence of these clusters in the regions and their GRP. Therefore, it is safe to conclude that the presence of industrial clusters in the regions is generally associated with higher levels of the GRP in the regions in the current and short-term periods. However, in the long five-year term, only a number of clusters show a significant positive correlation.

Thus, in general, there is a positive correlation between the presence of an industrial cluster in the region and the size of the gross regional product. As a result, it is possible to conclude that there are externalities (Marshall 1890; Arrow 1962; Romer 1986). In other words, specialization of regions on certain types of activities can generate positive effects for a region.

Likewise, based on the obtained data, it can be concluded that there is a significant positive correlation between the level of regional cluster specialization and the level of the GRP as presented in Table 1. This correlation is maintained in both, the short and long terms, explaining 30.4% and 32.1% of the variation respectively. In general, each additional 'star' assigned to a region based on the analysis of its cluster specialization parameters is associated with higher GRP levels in both the short and long terms. This means that an increase in the level of cluster specialization of any cluster in the region will have a positive effect on the volumes of the GRP concluding the second hypothesis test.

Table 1: Level of cluster structure development on the volumes of the GRP

Level of cluster specialization	Equation 4	Equation 5	Equation 6
Level of cluster structure development in the current period	0.0581*** (0.00461)		
Level of cluster structure development in period *t-1*		0.0602*** (0.00455)	
Level of cluster structure development in the reference period (2011)			0.0599*** (0.00438)
Constant	11.65*** (0.0848)	11.63*** (0.0828)	11.65*** (0.0795)
Number of observations	400	400	400
R^2	0.285	0.305	0.321
R^2 adjusted	0.283	0.304	0.319
Root mean square error	0.935	0.922	0.908

Source: Authors' own calculation.

Note: Standard regression coefficient errors are presented in brackets; ***p<0.01, **p<0.05, *p<0.1 are the levels of coefficient significance

The result strongly supports that higher cluster specialization in a region produces positive agglomeration effects due to a higher geographical concentration and co-location of clusters in the constituent entities of the Russian Federation. Thus, the second hypotheses is hereby been confirmed that the development of regional cluster specialization has a positive effect on the volumes of the GRP in the regions.

The result also shows that it is possible to confirm the presence of positive externalities emerging as a result of specialization of economic activity of the Russian regions. That is, concentration of many clusters with sufficient critical mass in one region leads to generation of positive effects for the region as a whole. These positive effects are manifested as an average difference in Gross Regional Product between regions with high and low specialization of their economies and are preserved in both short and long term periods. In other words, if a region initially had higher specialization, its GRP would be higher in the future than in regions with lower specialization.

The main aspects of the theory by Marshall, Jacobs, and Porter were considered within the framework of this study. Based on the analysis of scientific literature and international practice of using localization indicator as a basis for identification and comprehensive analysis of the level of cluster development, the most promising methods and approaches were identified as the methodology developed by a representative of the European Cluster Observatory. The method was chosen because it allows the evaluation of the relative level of development of cluster specialization in the region.

Conclusions

Based on the results of these calculations using 'Location quotient', 'Cluster size', and 'Cluster focus' indicators for 37 clusters in 83 regions of the Russian Federation in the period from 2009 to 2018, the level of cluster specialization of each region was assessed. Later, the influence of the level of cluster specialization development in a region on the GRP size was assessed and results confirmed hypotheses that there is a positive correlation between the level of cluster specialization development in the region and the GRP size in the period from 2011 to 2015. This shows positive agglomeration effects from high cluster specialization of the region confirming the hypothesis on the positive interrelations between regional specialization and volumes of GRP.

The scientific novelty of the work lies in identification of the cluster structure in the Russian Federation, development of a software solution that allowed automatic calculation of cluster localization in the regions of the Russian Federation. Other contribution of work is the generation of a report on the state of clusters, as well as a proof of positive externalities of individual clusters for regional development of the Russian economy. Besides, the paper used information and analytical systems for calculations and mapping the cluster structure, which allowed automating routine operations and presenting results in the form of tables and diagrammatic maps. Thus, the results obtained and the developed analytical tools can serve as a guideline for developing and justifying the state cluster policy and for evaluation of investment effectiveness, aimed at stimulating cluster development of the regional economy.

The authors plan to expand and modify the methodology proposed by representatives of the European Cluster Observatory and use it to assess the level of cluster localization in the given territory and other parameters characterizing the clusters. Therefore, it will be possible to measure not only the cluster specialization of the region, but also its strength, expressed in the success of the cluster in terms of dynamics of change in its economic indicators.

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Appendix 1: Regions of the Russian Federation where Biopharmaceuticals cluster is localized. Designations: LQ - location quotient, Size - cluster size, Focus – cluster focus, E_{ig}- the number of employees in the Biopharmaceuticals cluster in a region, E_g- the total number of employees in a region

Year Parameter	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
					Moscow region					
E_g, thous. persons	2,155.95	2,170.34	2,066.43	2,016.24	2,067.07	2,084.22	2,062.98	2,057.16	2,127.63	2,189.86
E_{ig}, thous. persons	13.82	14.06	13.86	14.55	14.63	15.36	15.89	16.28	17.53	18.07
Number of stars, pcs.	3	3	3	3	3	3	3	3	3	3
LQ	2.99	2.86	2.92	3.29	3.20	3.28	3.36	3.14	2.95	3.11
Size, %	13.57	13.27	13.15	14.45	14.43	15.05	15.35	14.52	14.17	15.44
Focus, %	0.64	0.65	0.67	0.72	0.71	0.74	0.77	0.79	0.82	0.83
					Moscow					
E_g, thous. persons	5,110.34	5,030.07	4,459.35	4,802.70	4,700.49	4,755.95	4,662.12	4,738.81	4,805.08	4,840.56
E_{ig}, thous. persons	15.47	15.23	15.35	12.59	13.11	13.34	12.67	17.45	25.36	18.12
Number of stars, pcs.	2	2	2	1	1	1	1	2	2	2
LQ	1.41	1.33	1.50	1.19	1.26	1.25	1.18	1.46	1.89	1.41
Size, %	15.18	14.37	14.56	12.50	12.93	13.08	12.24	15.57	20.49	15.49
Focus, %	0.30	0.30	0.34	0.26	0.28	0.28	0.27	0.37	0.53	0.37
					Saint Petersburg					
E_g, thous. persons	2,015.56	2,008.63	2,024.78	2,031.62	2,042.93	2,057.65	2,055.34	2,058.77	2,055.99	2,082.70
E_{ig}, thous. persons	5.99	9.28	7.60	8.04	8.16	8.36	9.36	9.48	10.84	10.66
Number of stars, pcs.	2	2	2	2	2	2	2	2	2	2
LQ	1.38	2.04	1.63	1.80	1.80	1.81	1.98	1.83	1.89	1.93

Year Parameter	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Size, %	5.88	8.76	7.21	7.98	8.05	8.19	9.04	8.46	8.76	9.11
Focus, %	0.30	0.46	0.38	0.40	0.40	0.41	0.46	0.46	0.53	0.51
	Novosibirsk region									
E_g, thous. persons	844.25	885.80	907.03	927.93	929.01	950.62	927.41	902.80	927.33	939.08
E_{ig}, thous. persons	3.40	3.55	3.78	3.88	4.06	4.14	4.26	4.58	4.94	5.19
Number of stars, pcs.	2	2	2	2	2	2	2	2	2	3
LQ	1.88	1.76	1.81	1.90	1.98	1.94	2.00	2.01	1.91	2.08
Size, %	3.34	3.35	3.58	3.85	4.01	4.06	4.11	4.09	3.99	4.43
Focus, %	0.40	0.40	0.42	0.42	0.44	0.44	0.46	0.51	0.53	0.55
	Tula region									
E_g, thous. persons	492.15	485.24	482.45	464.92	459.38	451.63	445.99	442.93	440.54	442.61
E_{ig}, thous. persons	3.01	3.33	3.39	3.52	3.29	3.23	3.31	3.55	2.75	3.59
Number of stars, pcs.	2	2	2	3	2	2	3	3	2	3
LQ	2.85	3.02	3.06	3.45	3.23	3.19	3.23	3.17	2.24	3.06
Size, %	2.96	3.14	3.22	3.50	3.24	3.16	3.20	3.16	2.22	3.07
Focus, %	0.61	0.69	0.70	0.76	0.72	0.71	0.74	0.80	0.62	0.81
	Kursk region									
E_g, thous. Persons	352.57	339.80	336.68	330.21	329.82	327.86	326.21	321.07	318.45	323.38
E_{ig}, thous. persons	1.87	1.80	2.06	1.60	1.70	1.77	1.86	2.03	2.29	2.14
Number of stars, pcs.	2	2	2	2	2	2	2	2	2	2

Year Parameter	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
LQ	2.47	2.34	2.66	2.20	2.32	2.41	2.48	2.51	2.58	2.49
Size, %	1.83	1.70	1.95	1.59	1.67	1.74	1.79	1.81	1.85	1.83
Focus,%	0.53	0.53	0.61	0.48	0.51	0.54	0.57	0.63	0.72	0.66
	Kurgan region									
E_g, thous. persons	271.19	267.96	255.53	254.61	253.31	247.52	238.96	231.27	221.72	219.90
E_{ig}, thous. persons	3.63	3.63	3.40	3.09	2.85	2.77	2.88	2.94	2.92	2.72
Number of stars, pcs.	3	3	2	2	2	2	2	2	2	2
LQ	6.24	5.96	5.79	5.52	5.09	4.99	5.24	5.04	4.71	4.67
Size, %	3.57	3.42	3.23	3.06	2.81	2.72	2.78	2.62	2.36	2.32
Focus, %	1.34	1.35	1.33	1.21	1.13	1.12	1.20	1.27	1.32	1.24
	Kaluga region									
E_g, thous. persons	337.96	333.10	333.61	342.84	345.41	347.06	337.42	321.85	318.40	321.54
E_{ig}, thous. persons	0.65	0.55	0.79	0.74	0.78	1.07	1.07	1.78	1.52	2.22
Number of stars, pcs.	0	0	0	0	0	1	1	2	1	2
LQ	0.90	0.72	1.02	0.98	1.02	1.38	1.38	2.20	1.71	2.61
Size, %	0.64	0.52	0.74	0.73	0.77	1.05	1.04	1.59	1.23	1.90
Focus, %	0.19	0.16	0.24	0.21	0.22	0.31	0.32	0.55	0.48	0.69

Source: 'Number of stars, pcs.', 'LQ', 'Size, %', 'Focus, %' - Authors' own calculation

Note: 'E_g, thous. persons', 'E_{ig}, thous. persons' – collected from (Federal Statistical Service 2017,2019)

Appendix 2: Results of the analysis on the presence/absence of clusters on the GRP level

Models Variables	Equation 1 Coefficients with variable $Cluster_{jit}$	Equation 2 Coefficients with variable $Cluster_{jit-1}$	Equation 3 Coefficients with variable $Cluster_{ji2011}$
	High technology clusters		
Automotive Industry	0.326***	0.382***	0.370**
	(0.0293)	(0.0509)	(0.166)
Analytical Tools	0.439***	0.439***	0.404**
	(0.0355)	(0.0354)	(0.154)
Aerospace Engineering	0.918***	0.872***	1.194***
	(0.103)	(0.148)	(0.142)
Biopharmaceutics	0.556***	0.612***	0.856***
	(0.0897)	(0.0857)	(0.148)
Information Technology	1.300***	1.304***	1.242***
	(0.122)	(0.139)	(0.173)
Medical Instruments	0.538***	0.367***	0.175
	(0.165)	(0.119)	(0.174)
Telecommunications	0.121***	0.143***	-0.092
	(0.0217)	(0.0433)	(0.161)
Production Equipment	0.909***	0.918***	0.940***
	(0.0643)	(0.119)	(0.160)
Lighting and Electrical Equipment	0.222***	0.232***	0.226
	(0.0261)	(0.0350)	(0.160)
Heavy Engineering	0.200***	0.184***	0.206
	(0.0250)	(0.0247)	(0.160)
	Traditional clusters		
Plastics	0.499***	0.577***	0.559***
	(0.0734)	(0.149)	(0.158)
Steel Industry	0.620***	0.649***	0.694***
	(0.0350)	(0.0609)	(0.164)
Chemical Industry	0.805***	0.801***	0.873***
	(0.0512)	(0.0574)	(0.170)
Shoes	0.128*	0.183***	0.249
	(0.0666)	(0.0574)	(0.120)
Clothing	-0.254***	-0.309***	-0.422**

Models Variables	Equation 1 Coefficients with variable Cluster_{jit}	Equation 2 Coefficients with variable Cluster_{jit-1}	Equation 3 Coefficients with variable Cluster_{ji2011}
	(0.0568)	(0.0569)	(0.174)
Construction Technology	0.167***	0.206**	0.019
	(0.0557)	(0.0843)	(0.184)
Construction	0.979***	1.063***	1.175***
	(0.169)	(0.156)	(0.187)
Paper Products	0.307***	0.323***	0.246
	(0.0195)	(0.0179)	(0.160)
Textile	-0.169***	-0.0824	-0.170
	(0.0150)	(0.0773)	(0.167)
Stone Quarries	-0.0344	-0.0251	-0.0251
	(0.0326)	(0.0259)	(0.175)

Source: Authors' own calculation

Note: Standard regression coefficient errors are presented in brackets; *** p<0.01, ** p<0.05, * p<0.1 are the levels of coefficient significance

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MODELING CLUSTER DEVELOPMENT USING PROGRAMMING METHODS: CASE OF RUSSIAN ARCTIC REGIONS*

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Abstract. The aim of this research is to show how the process of data analysis can be automated through development of an information system. The information system can be used for the identification of economic clusters and analysis of the regional potential for economic growth. The authors used data on the Russian Arctic regions with extreme social, geographical, and economic conditions collected from 2009 to 2016 as an example. The authors have designed a database using MS Access software. The authors used the methodology of the European cluster observatory and the approach suggested by M. Porter to identify economic clusters. This methodology was complemented by introduction parameters, which mirror the strength and employment dynamic of the clusters. Based on the employment data of 83 Russian regions during the period of 2009–2016 the authors have calculated cluster localization parameters for nine Russian regions, which are partly or fully located in the Arctic zone. The authors suggest that the cluster structure in this area is weak and most of the significant clusters are declining. The only significant cluster, which is growing in all regions, is the «Oil and Gas» cluster. In conclusion, the authors state that the obtained results are vital for policy makers and can be used for elaborating the regional economic development strategy in order to support regional diversification and specialization, which are closely related to positive spillovers.

Keywords: Arctic region, economic cluster, cluster identification, MS access, data processing, regional policy making

Reference

JEL Classifications

1. Introduction

Creating conditions for the economic development of regions is one of the most important tasks for regional governments, who nowadays, in large part, are supported by informational systems (Morrissey, 2016; Rytova & Gutman, 2019). During this process, a regional government should take into account social, economic, and geographical factors, which can affect the development of each concrete territory (Andreyeva et al., 2018; Dvas et al., 2018; Baltgailis, 2019; Petrenko et al., 2019).

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A combination of these factors determines whether a certain region will or will not be capable of developing industries which will be competitive at national and international scales. Consequently, analysts should process multidimensional data which reflect the current situation. Based on such analyses, they should receive specific results, which can be used for determining potential directions for development of the region (Degtereva et al., 2018; Kichigin, 2017; Kozlov et al., 2017; Thill, 2019). Therefore, it is essential to develop informational systems to support and enhance the processes of policy making and, consequently, positively affect regional economic development (Chun et al., 2010; Höchtl et al., 2016; Velasquez & Hester, 2013; Prodani et al., 2019).

A cluster approach to regional economic development put forth by Porter (1998) and developed further by a number of authors (Delgado et al., 2014, 2015; Tvaronavičienė, 2017; Tvaronavičienė & Razminienė, 2017; Razminienė & Tvaronavičienė, 2018; Bublienė et al., 2019), is one of the most innovative and effective tools for policy implementation. The results of applying a cluster approach in American (Gupta, et al., 2006; Guzman & Stern, 2015; Peiró-Signes, et al., 2015; Porter et al., 2011), European (Crawley & Pickernell, 2012; Looijen & Heijman, 2013; Sellar, et al., 2011) and Russian (Islankina & Thurner, 2018; Kutsenko et al., 2017; Rodionova et al., 2017) territories are widely represented in scientific literature. However, these applications are lacking in two main aspects which are essential for using this approach effectively in practice. The first aspect is that most of them are focused on receiving results, rather than making the process reproducible and applicable for other researches and practitioners. The second aspect is that they aim at finding global linkages between some factors and the level of cluster development (Akpinar et al., 2017; MATICIUC, 2015), but do not focus on concrete results for a concrete set of territories with extreme social, economic, and geographical conditions. This gap may lead to the development of a «cure» which is suitable for all territories, but in some extreme cases is ineffective and should be combined with some «additives». Therefore, it is necessary to describe how we can create an information system which will provide an analytical background for the development of the cluster-based policy and give examples of applying these results in territories with extreme social, economic, and geographical conditions.

As an example of such territories, we have chosen Russian regions which are partly or fully located in the Arctic zone (Leksin & Porfiryev, 2017). These are poorly developed territories which have a certain economic potential (Borisov & Pochukaeva, 2016; Komkov, et al., 2017; Korovkin, 2016). Developing these territories is claimed to be one of the top priorities for a balanced development of the Russian Federation (Gutman et al., 2018; Romashkina et al., 2017; Tatarkin et al., 2017). Developing an effective cluster-based policy, which relies on the results of comprehensive and multidimensional analysis, is key for long-term socioeconomic growth of the Russian Arctic regions (Komkov et al., 2017; Rytova et al., 2017).

Therefore, the aim of this research is to show how, through development of an information system, the process of data analysis can be automated, which is necessary for identifying and analyzing economic clusters. In addition, we demonstrate a potential approach to cluster structure analysis of the Russian Arctic regions, which have both extreme social, geographical, and economic conditions and a potential for economic growth, during 2009–2016.

2. Data and methods

2.1. Data and cluster identification methodology

In order to gather the information necessary for calculating the parameters of cluster localization, we obtained detailed data on employment from three main sources: the joint economic and social data archive of the Higher School of Economics (HSE, 2018), the Central Statistical Database of Russia (Federal State Statistics Service, 2019), and United Interdepartmental Information-Statistical Service (MinComSvyaz, 2019). These sources provide official data obtained from the Russian Federal State Statistics Service. We used data from united

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interdepartmental information-statistical service as the main source of data, as it is better structured and contains more information. In some cases, when there were not enough data for some of the regions, we used data from the central statistical database of Russia and the joint economic and social data archive of the Higher School of Economics. The data were organized in the form presented in Table 1. As a result, we received 28044 observations for calculating the localization parameters of 37 clusters for 83 regions of Russia for the period of 2009–2016.

Table 1. Specifying the data used for identifying economic clusters in Russia

Federal District	Region	Year	Cluster	OKVED codes	Number of the employed
List of 8 Federal Districts, which include Russian regions	List of 83 Russian regions	Identifying the time: 2009–2016	List of 37 clusters, identified according to M. Porter's classification for each region	Each of the 37 clusters is composed of several OKVED codes. Therefore, for each cluster, we detail its composition	For each code we filled the number of people employed in the region
Employment statistics by activity type were obtained from: (HSE, 2018), (Federal State Statistics Service, 2019), (MinComSvyaz, 2019). Authors composed clusters based on employment statistics of separate types of activities, presented in each region.					

We follow the methodology developed by Porter (1998), which is now used by the U.S. Mapping project and the European Cluster Observatory for identifying and monitoring cluster development. In particular, we use three coefficients which show the localization properties of each cluster: localization, focus, and size. This methodology was presented in detail by both developers (Ketels & Protsiv, 2014), their followers (Kopczewska, 2018; Kopczewska et al., 2017) and the authors of this research study (Berawi, 2017; Berawi et. al., 2018; Schepinin et. al., 2018) in earlier works. The European Cluster Observatory defined these three factors as the «Localization coefficient» (1), «Size» (2), and «Focus» (3). The values of the factors, within the threshold values, reflects whether the examined cluster has or has not achieved a sufficient «critical mass» to generate positive external effects and relations. These indicators are calculated using employment statistics and are reflected in the following formulae:

$$LQ = \frac{E_{ig}}{E_g} / \frac{E_i}{E}, \qquad (1)$$

where LQ is the «Localization coefficient»; E_{ig} is the number of people employed in cluster i in region g; E_g is the total number of people employed in region g; E_i is the number of people employed in cluster i; and E is the total number of people employed.

$$Size = \frac{E_{ig}}{E_i}, \qquad (2)$$

where Size is the «Size» of cluster i; E_{ig} is the number of people employed in cluster i in region g; and E_i is the number of people employed in cluster i.

$$Focus = \frac{E_{ig}}{E_g}, \qquad (3)$$

where Focus is the «Focus» of cluster i; E_{ig} is the number of people employed in cluster i in region g; and E_g is the number of people employed in region g.

G. Lindqvist, a Swedish economist from the European Cluster Observatory (Lindqvist, 2009), establishes the following criteria as the threshold values, which mark significant cluster groups in a region:

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1) «Localization coefficient» ≥ 2;
2) the region should be included in top 10% in «Size»;
3) the region should be included in top 10% in «Focus».

In addition, a region cannot receive a star if critical mass of the cluster is less than 1000 employed people.
If a criterion is fulfilled, the cluster earns one «star». Thus, the maximum a cluster can receive is three «stars». The number of «stars» determines the strength of the cluster group

Table 2. Level of region specialization in types of activities performed by cluster i in region g

Level of region specialization	Average number of stars, obtained by cluster i in region g
High	(2.3; 3]
Medium	(1.7; 2.4]
Low	[1; 1.7]
Region has no specialization in this type of activity	[0; 1)

Source: Compiled by aurhors

In order to systemize the results and present them more clearly, we also separate regions by two dimensions: the level of specialization in types of activities, performed by cluster *i* (Table 2) in region *g* and the dynamic state of employment of cluster *i* in region *g* (Table 3). We have built dimension «levels of region specialization» in types of activities performed by cluster *i* in region *g* based on the average number of stars which cluster *i* in region *g* receives for the analyzed period, while the second dimension is based on the employment dynamics, calculated through the growth rate:

$$GR_{t=0} = \left(\frac{x_{igt\geq 1}}{x_{igt=0}} - 1 \right) \times 100\% \qquad (4)$$

$$GR_{t} = \left(\frac{x_{igt+1}}{x_{igt}} - 1 \right) \times 100\% \qquad (5)$$

The growth rate allows estimating the change in clusters' critical mass and reflecting the dynamic aspect of cluster growth, where $x_{igt=0}$ is the number of people employed in cluster *i* in region *g* at the beginning ($t = 0$) of the analyzed period, and x_{igt} is the number of people employed in cluster *i* in region *g* at the time $t \geq 1$ and x_{igt+1} - at the time $t + 1$. $GR_{t=0}$ is the measure for calculating long-term employment dynamics, while GR_t is used for the short-term. In Table 3 we propose a possible classification of dynamic states of the cluster depending on the values of $GR_{t=0}$ and GR_t at the end of the period and their overall dynamics. It complements the existing localization measures, since the main problem of the «Size», «Focus», and «Localization coefficient» is their independence from the time trend. It means that if employment of the cluster, employment of the whole cluster group, and total employment are decreasing, the «Localization coefficient» remains stable, and vice versa, since it cannot catch up with dynamic changes in employment in certain cases.

Table 3. Types of dynamic state of employment of cluster *i* in region *g*

Dynamic state	Characteristic	Interval for $GR_{t=0}$ and GR_t, %
Strong growth	Strong positive employment dynamics	[10; +∞)
Moderate growth	Moderate positive employment dynamics	[5; 10)
Stable	Stable employment dynamics with slight changes in employment	(-5; +5)
Unstable	Employment dynamics with rough positive and/or negative changes at the beginning, in the middle or at the end of the period	[5; +∞) and/or (-∞; -5]
Moderate decrease	Moderate negative employment dynamics	(-10; -5]
Strong decrease	Strong negative employment dynamics	(-∞; -10]

Source: Compiled by aurhors

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2.2. Description of information system used for automated cluster identification

The database «Clusters of Russia's Regions» was developed and registered in 2017 in order to support research of the cluster structure in Russia. During the development process, we wanted to achieve the following objectives:

- structuring and rationalizing big data concerning employment in different clusters in the Russian regions;
- creating a convenient system for data input and editing;
- creating a computing mechanism for estimating the localization coefficients for clusters in a certain year;
- creating a flexible system which can be modified in case some regions have to be added or new clusters have to be defined;
- automating the estimation results and converting them into analytical reports.

A user receives the results of analysis in the form of summary tables, where main results are given for each region and each cluster. The results are calculated in accordance with the methodology discussed in Paragraph 2.1.

Based on the research of the data structure we created four entities: «Federal District», «Region», «Cluster», and «Employment». These entities allow us to minimize input errors and provide integrity of data. The entity «Federal District» has two attributes: an identifier (which is a primary key), and a label. This table is a glossary, which provides secure and convenient input of data in interconnected objects and access to the groups of regions. The entity «Region» belongs only to one Federal District and cannot exist independently. Therefore, apart from its own primary key, it has a secondary key for connection with the entity «Federal District». The entity «Cluster» has two main attributes: a short label and a named key. Additional attributes are used for interface organization, because long labels take too much space and are not suitable for usage in headlines and summary tables. The entity «Employment» contains two external keys for connection with «Region» and «Cluster» and a nested primary key, which protects the table from data duplication since only one cluster i can be created for each region in a certain time period. Therefore, each cluster can be uniquely determined through such attributes as year, region, and cluster. For the sake of convenient data processing, we have also added a counter, which defines the unique nested key. The database evaluates the following attributes: «Localization coefficient», «Size», «Focus», and «Number of stars» (Table 4).

Table 4. Attributes of entity «Employment»

Attribute title	Attribute label
Year	YearEpml
Region	IdRegion
Cluster	IdIndustry
Emp_{ig}	Empig
Size	Esize
Focus	EFocus
LQ	ELQ
Stars	Estars

Source: Compiled by aurhors

In order to organize the data input and provide immediate access to the clusters, a temporary entity, «Computation», with a varying number of attributes, has been introduced. It adapts for each region and cluster in a specific time period.

The physical model is SQL-based and realized in DBMS MS Access 2007 (Figure 1).

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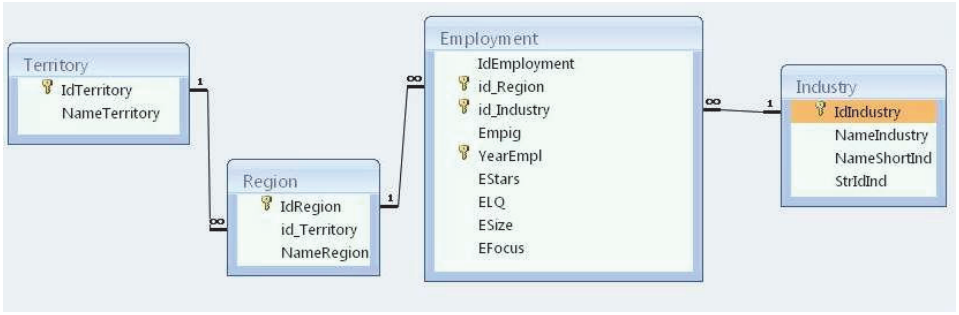
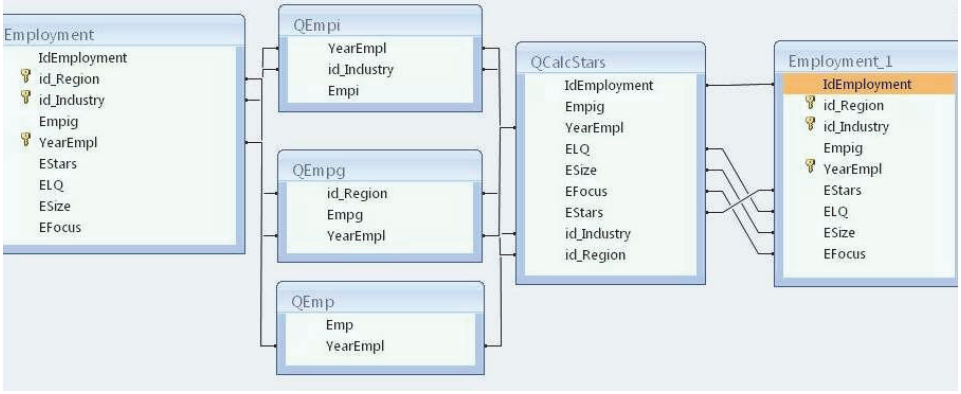


Source: Compiled by Authors
Figure 1. Physical model of «Clusters of Russia's Regions».

The table «Employment» contains data, which is used for calculation and data processing. Other tables provide a safe and convenient form for data input and make the main table free from redundant data. Using equations 1–3 the program calculates total employment by each region, each cluster, and each year. In order to implement calculations, we developed a chain of query operators and the function CalcStars (Figure 2). The program calculates the results and inputs them into the main table. The data from this table has to be analyzed and selected for display. A chain of query operators for displaying the result is presented in Figure 3.



Source: Compiled by Authors
Figure 2. A calculation model of the database

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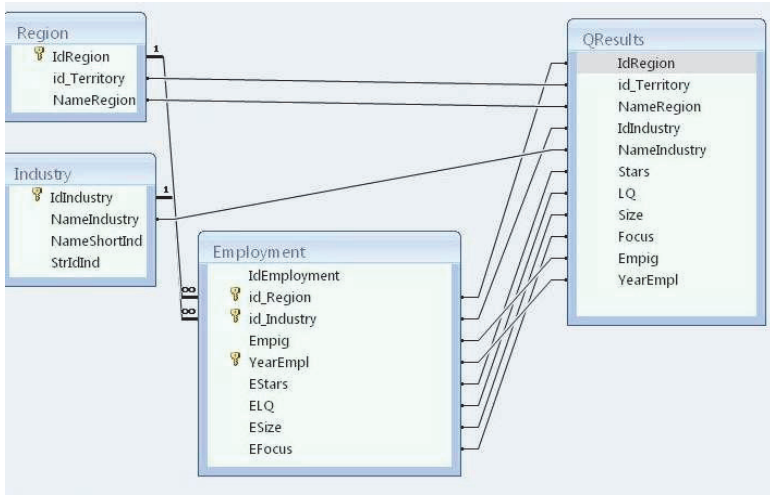

Source: Compiled by Authors
Figure 3. A chain of query operators for displaying the result

3. Results of database application

3.1. General information

In accordance with the methodology for cluster identification discussed in Section 2.1 and the database design presented in section 2.2, we have received analytical results for all 83 Russian regions for the 2009–2016 period.

Source: Compiled by Authors
Figure 4. The map of Russian regions, which are fully or partly located in the Arctic zone

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Here we discuss only the results obtained for the Russian regions, which are partly or fully located in the Arctic zone. These regions are the following:

- Murmansk Oblast;
- Chukotka Autonomous Okrug;
- Komi Republic;
- Arkhangelsk Oblast including Nenets Autonomous Okrug;
- Yamalo-Nenets Autonomous Okrug;
- Sakha Republic;
- Republic of Karelia;
- Krasnoyarsk Krai;
- Khanty-Mansi Autonomous Okrug.

The geographical location of the regions we analyze is presented in Figure 4. Next, we present a detailed analysis of cluster specialization of each Arctic region of Russia and, after that, aggregate the results for all arctic regions.

Komi Republic cluster specialization analysis

The overall employment dynamic in Komi Republic was negative. The total number of employed people decreased by 13.97% or by 53,967 people over eight years. Analyzing the employment statistics in Komi Republic during the period of 2009–2016, we have detected five clusters: Transportation and Logistics, Oil and Gas, Paper Products, Business Services, and Construction, with all of them receiving at least one star. It means that the level of localization of these clusters, at least in one year, was relatively high in accordance with the values of the «Localization Coefficient», «Size», and «Focus». The detailed results are presented in Table 5.

Komi Republic had a medium specialization level in Transportation and Logistics and the critical mass of this cluster was unstable during the analyzed period. After a decrease of the clusters' employment by 1.07% in 2010, there was a significant growth of the clusters' critical mass from 36,403 up to the 43,756 people; that is, by 19.7% in 2012. After that, there was a stable decrease in the Transportation and Logistics cluster's critical mass: 19.35% in 2016 compared to 2012. Nevertheless, the overall specialization of the region in Transportation and Logistics activities remained at a medium level, since two localization measures out of three fulfilled the threshold requirements.

Komi Republic had a high specialization level in Oil and Gas and the critical mass of this cluster grew significantly during the analyzed period, despite some falls in 2011 and 2016. The overall increase of the cluster's critical mass was 25.76% over eight years. This resulted in a stronger specialization of the cluster and its stabilization at the high level, since three out of three localization measures fulfilled the threshold requirements.

Komi Republic had a high specialization level in Paper Products and the critical mass of its cluster substantially decreased during the period of 2009-2016. The overall decrease of the clusters' critical mass was 27.61% over eight years. In addition, the decrease in the critical mass of the Paper Products cluster in Komi Republic was significantly greater than the overall decrease in the critical mass of the Paper Products Cluster, being 27.61% compared to 4.78%. It resulted in Komi Republic losing one star of cluster specialization in 2016, since one of the three localization measures did not fulfill the threshold requirements.

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Komi Republic lost specialization in Business Services in 2012, since the cluster's critical mass decreased by 23.02% over eight years, while the cluster's overall critical mass increased by 7.41%. The breakpoint was in 2011–2012, when two localization measures did not fulfill the threshold requirements.

Specialization of Komi Republic in Construction was detected in the period of 2012–2013, when a sudden increase in employment levels brought about a fall in the construction cluster localization. However, it was a short-term increase, which did not allow the regional specialization to strengthen in the long run. Therefore, the long-term decrease of the cluster's critical mass in Komi Republic was 21.80%.

Table 5. Employment-based parameters of significant clusters in Yamalo-Nenets AO

Year / Parameter	2009	2010	2011	2012	2013	2014	2015	2016
Common employment parameters								
E (people)	47427502	46719007	45872388	45898382	45815640	45486400	45106533	44446352
E_g (people)	386402	382869	383163	382155	373393	360442	347562	332435
Transportation and Logistics cluster parameters								
E_i (people)	3489740	3370683	3371228	3400956	3360962	3377649	3352174	3308218
E_{ig} (people)	36797	36403	41187	43756	41241	39560	37282	35289
GR_t (%)		-1.07	13.14	6.24	-5.75	-4.08	-5.76	-5.35
$GR_{t=0}$ (%)		-1.07	11.93	18.91	12.08	7.51	1.32	-4.10
Number of stars	1	1	2	2	2	2	2	2
LQ	1.29	1.32	1.46	1.55	1.51	1.48	1.44	1.43
Size (%)	1.05	1.08	1.22	1.29	1.23	1.17	1.11	1.07
Focus (%)	9.52	9.51	10.75	11.45	11.04	10.98	10.73	10.62
Oil and Gas cluster parameters								
E_i (people)	504955	504478	517301	536739	556754	578881	594546	606641
E_{ig} (people)	14858	15782	15357	15699	16624	18676	19911	18685
GR_t (%)		6.22	-2.69	2.23	5.89	12.34	6.61	-6.16
$GR_{t=0}$ (%)		6.22	3.36	5.66	11.89	25.70	34.01	25.76
Number of stars	3	3	3	3	3	3	3	3
LQ	3.61	3.82	3.55	3.51	3.66	4.07	4.35	4.12
Size (%)	2.94	3.13	2.97	2.92	2.99	3.23	3.35	3.08
Focus (%)	3.85	4.12	4.01	4.11	4.45	5.18	5.73	5.62
Paper Products cluster parameters								
E_i (people)	137015	136152	137499	136273	132216	128119	125839	130471
E_{ig} (people)	4810	4709	4444	4195	4181	3769	3611	3482
GR_t (%)		-2.10	-5.63	-5.60	-0.33	-9.85	-4.19	-3.57
$GR_{t=0}$ (%)		-2.10	-7.61	-12.79	-13.08	-21.64	-24.93	-27.61
Number of stars	3	3	2	3	3	3	3	2
LQ	4.31	4.22	3.87	3.70	3.88	3.71	3.72	3.57
Size (%)	3.51	3.46	3.23	3.08	3.16	2.94	2.87	2.67
Focus (%)	1.24	1.23	1.16	1.10	1.12	1.05	1.04	1.05
Business services cluster parameters								
E_i (people)	2969478	2921201	2880799	3146204	3237312	3272631	3257275	3189467
E_{ig} (people)	32156	32050	31026	29169	27946	26602	26282	24755
GR_t (%)		-0.33	-3.20	-5.99	-4.19	-4.81	-1.20	-5.81
$GR_{t=0}$ (%)		-0.33	-3.51	-9.29	-13.09	-17.27	-18.27	-23.02
Number of stars	2	2	1	0	0	0	0	0
LQ	1.33	1.34	1.29	1.11	1.06	1.03	1.05	1.04
Size (%)	1.08	1.10	1.08	0.93	0.86	0.81	0.81	0.78
Focus (%)	8.32	8.37	8.10	7.63	7.48	7.38	7.56	7.45
Construction cluster parameters								
E_i (people)	3425797	3430749	3163493	3254308	3225983	3123938	2983398	2800194
E_{ig} (people)	28568	28673	29713	35404	34969	29572	24566	22340
GR_t (%)		0.37	3.63	19.15	-1.23	-15.43	-16.93	-9.06

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GR$_{t=0}$ (%)		0.37	4.01	23.93	22.41	3.51	-14.01	-21.80
Number of stars	0	0	0	1	2	0	0	0
LQ	1.02	1.02	1.12	1.31	1.33	1.19	1.07	1.07
Size (%)	0.83	0.84	0.94	1.09	1.08	0.95	0.82	0.80
Focus (%)	7.39	7.49	7.75	9.26	9.37	8.20	7.07	6.72
Source: Employment statistics were obtained from: (HSE, 2018), (Federal State Statistics Service, 2019), (MinComSvyaz, 2019) Calculations were performed by authors.								

Out of the five clusters identified in Komi Republic during 2009–2016, only two clusters had a relatively high critical mass, which was enough for the region to have specialization in these types of activities. One cluster was decreasing—Paper Products—and one was growing—Oil and Gas. In addition, the region had medium specialization in Transportation and Logistics, which had unstable growth rates. The Business Services cluster was decreasing steadily, which resulted in Komi Republic losing specialization in this type of activity, and the Construction Cluster showed unstable employment dynamics.

Yamalo-Nenets AO cluster specialization analysis

The overall employment dynamic in Yamalo-Nenets AO was positive. The total number of people employed increased by 5.65%, or by 18,018 people over eight years. Analyzing Yamalo-Nenets AO employment statistics during the period of 2009–2016, we detected five clusters: Transportation and Logistics, Maritime, Oil and Gas, Business Services, and Construction, which have received at least one star. Detailed results are presented in Table 6.

Table 6. Employment-based parameters of significant clusters in Yamalo-Nenets AO

Year / Parameter	2009	2010	2011	2012	2013	2014	2015	2016
Common employment parameters								
E (people)	47427502	46719007	45872388	45898382	45815640	45486400	45106533	44446352
E$_g$ (people)	319089	314503	311693	328308	333527	329129	331108	337107
Transportation and Logistics cluster parameters								
E$_i$ (people)	39386	35633	36513	40414	41824	37802	34637	34997
E$_{ig}$ (people)		-9.53	2.47	10.68	3.49	-9.62	-8.37	1.04
GR$_t$ (%)		-9.53	-7.29	2.61	6.19	-4.02	-12.06	-11.14
GR$_{t=0}$ (%)	2	2	2	2	2	2	2	2
Number of stars	1.68	1.57	1.59	1.66	1.71	1.55	1.41	1.39
LQ	1.13	1.06	1.08	1.19	1.24	1.12	1.03	1.06
Size (%)	12.34	11.33	11.71	12.31	12.54	11.49	10.46	10.38
Focus (%)	39386	35633	36513	40414	41824	37802	34637	34997
Maritime cluster parameters								
E$_i$ (people)	148225	152423	136905	129441.6	126963	116436.8	116557	114799
E$_{ig}$ (people)	2468	2267	2212	2153	2151	2102	2110	2093
GR$_t$ (%)		-8.14	-2.43	-2.67	-0.09	-2.28	0.38	-0.81
GR$_{t=0}$ (%)		-8.14	-10.37	-12.76	-12.84	-14.83	-14.51	-15.19
Number of stars	1	1	1	1	1	1	1	1
LQ	2.47	2.21	2.38	2.33	2.33	2.49	2.47	2.40
Size (%)	1.67	1.49	1.62	1.66	1.69	1.81	1.81	1.82
Focus (%)	0.77	0.72	0.71	0.66	0.64	0.64	0.64	0.62
Oil and Gas cluster parameters								
E$_i$ (people)	504955	504478	517301	536739	556754	578881	594546	606641
E$_{ig}$ (people)	31962	31838	33940	35253	37616	39032	40693	41514
GR$_t$ (%)		-0.39	6.60	3.87	6.70	3.76	4.26	2.02
GR$_{t=0}$ (%)		-0.39	6.19	10.30	17.69	22.12	27.32	29.89
Number of stars	3	3	3	3	3	3	3	3
LQ	9.41	9.38	9.66	9.18	9.28	9.32	9.32	9.02
Size (%)	6.33	6.31	6.56	6.57	6.76	6.74	6.84	6.84

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Focus (%)	10.02	10.12	10.89	10.74	11.28	11.86	12.29	12.31
Business Services cluster parameters								
E_i (people)	2969478	2921201	2880799	3146204	3237312	3272631	3257275	3189467
E_{ig} (people)	20241	23056	24426	27574	28247	28332	29160	31328
GR_t (%)		13.91	5.94	12.89	2.44	0.30	2.92	7.43
$GR_{t=0}$ (%)		13.91	20.68	36.23	39.55	39.97	44.06	54.77
Number of stars	0	0	1	1	1	1	1	1
LQ	1.01	1.17	1.25	1.23	1.20	1.20	1.22	1.30
Size (%)	0.68	0.79	0.85	0.88	0.87	0.87	0.90	0.98
Focus (%)	6.34	7.33	7.84	8.40	8.47	8.61	8.81	9.29
Construction cluster parameters								
E_i (people)	3425797	3430749	3163493	3254308	3225983	3123938	2983398	2800194
E_{ig} (people)	49716	48086	44634	51707	52911	52487	53417	55937
GR_t (%)		-3.28	-7.18	15.85	2.33	-0.80	1.77	4.72
$GR_{t=0}$ (%)		-3.28	-10.22	4.00	6.43	5.57	7.44	12.51
Number of stars	2	2	2	2	2	2	2	2
LQ	2.16	2.08	2.08	2.22	2.25	2.32	2.44	2.63
Size (%)	1.45	1.40	1.41	1.59	1.64	1.68	1.79	2.00
Focus (%)	15.58	15.29	14.32	15.75	15.86	15.95	16.13	16.59
Source: Employment statistics were obtained from: (HSE, 2018), (Federal State Statistics Service, 2019), (MinComSvyaz, 2019) Calculations were performed by authors.								

Yamalo-Nenets AO had a medium specialization level in Transportation and Logistics and the critical mass of this cluster was unstable during the analyzed period. After a 9.53% decrease of the cluster's employment in 2010, there was a significant growth of the cluster's critical mass, from 35,633 up to 41,824 people employed; that is, by 17.3% in 2013 compared to 2010. After that, there was a stable decrease of the Transportation and Logistics cluster's critical mass: 16.32% in 2016 compared to 2013. Nevertheless, the overall specialization of the region in Transportation and Logistics activities remained at a medium level, since two localization measures out of three fulfilled the threshold requirements.

Yamalo-Nenets AO had a low specialization in Maritime. However, the critical mass of this cluster decreased by 15.19% during the analyzed period. The region still has a certain margin of safety in relative terms, since the overall employment in Maritime activities decreased by 22.55% over eight years. However, in terms of absolute values, the region was continuously losing its specialization in this type of activity.

Yamalo-Nenets AO had a high specialization level in Oil and Gas, and the critical mass of this cluster was growing significantly during the analyzed period. The overall increase of the cluster's critical mass was 29.89% over eight years. This resulted in a stronger specialization of the cluster and its stabilization at a high level, since three localization measures out of three fulfilled the threshold requirements.

Yamalo-Nenets AO was strengthening its specialization in Business Services, since the cluster's critical mass in Yamalo-Nenets AO increased by 54.07% over eight years, while the cluster's overall critical mass increased by 7.41%. The breakpoint was in 2011, when one localization measure fulfilled the threshold requirements.

Yamalo-Nenets AO had a medium specialization level in Construction and the critical mass of this cluster was unstable during the analyzed period. There was a 3.28% decrease in the cluster's employment in 2010, and a 7.18% decrease in 2011. After that, there was a significant growth of the cluster's critical mass, from 44,634 in 2011 up to 55,937 people; that is, by 25.32% in 2016. It resulted in a stronger specialization of the cluster and its stabilization at a high level, since two localization measures out of three fulfilled the threshold requirements.

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Yamalo-Nenets AO was strongly specialized in only one cluster, showing a steady growth of the critical mass—the Oil and Gas cluster. In addition, the region had a medium specialization in the Transportation and Logistics and Construction clusters, which had unstable growth rates. The Maritime cluster was decreasing considerably, which resulted in Yamalo-Nenets AO losing specialization in this type of activity. The Business Services cluster demonstrated an intensive growth, which resulted in a stronger specialization of the cluster, since one localization measure out of three fulfilled the threshold requirements.

Republic of Karelia cluster specialization analysis

The overall employment dynamic in the Republic of Karelia was negative. The total number of people employed decreased by 17.42%, or by 40,822 people over eight years. Analyzing employment statistics of the Republic of Karelia during the period of 2009–2016, we detected four clusters: Transportation and Logistics, Maritime, Paper Products, and Furniture, which received at least one star. Detailed results are presented in Table 7.

The Republic of Karelia had a low specialization level in Transportation and Logistics, and the critical mass of this cluster was steadily decreasing during the analyzed period. After an 8.15% decrease of the cluster's employment in 2010–2011, there was a slight growth of the cluster's critical mass from 23,972 up to 24,285 people employed; that is, by 1.31% in 2013 compared to 2012. After that, there was a stable decrease in the Transportation and Logistics cluster's critical mass: 18.04% in 2016 compared to 2012. Therefore, the long-term decrease of the cluster's critical mass in the Republic of Karelia was 23.74% over eight years. It resulted in the Republic of Karelia losing one star of cluster specialization in 2013, since two of the three localization measures did not fulfill the threshold requirements.

The Republic of Karelia had a low specialization in Maritime. However, the critical mass of this cluster was unstable. The region still has a certain margin of safety in relative terms, since the overall employment in Maritime activities decreased by 22.55% over eight years. However, in terms of absolute values, the region demonstrated a cyclic growth and a decrease of the critical mass by 9.01% over eight years. Nevertheless, the region gained one additional star in 2016, which can be attributed to the overall decrease of the Maritime critical mass.

Table 7. Employment based parameters of significant clusters in the Republic of Karelia

Parameter \ Year	2009	2010	2011	2012	2013	2014	2015	2016
General employment parameters								
E (people)	47427502	46719007	45872388	45898382	45815640	45486400	45106533	44446352
E_g (people)	234310	228336	226165	225442	220074	211446	205299	193488
Transportation and Logistics cluster parameters								
E_i (people)	3489740	3370683	3371228	3400956	3360962	3377649	3352174	3308218
E_{ig} (people)	26100	24582	23972	24285	23232	21923	21375	19903
GR_t (%)		-5.82	-2.48	1.31	-4.34	-5.63	-2.50	-6.89
$GR_{t=0}$ (%)		-5.82	-8.15	-6.95	-10.99	-16.00	-18.10	-23.74
Number of stars	2	2	2	2	1	1	1	1
LQ	1.51	1.49	1.44	1.45	1.44	1.40	1.40	1.38
Size (%)	0.75	0.73	0.71	0.71	0.69	0.65	0.64	0.60
Focus (%)	11.14	10.77	10.60	10.77	10.56	10.37	10.41	10.29
Maritime cluster parameters								
E_i (people)	148225	152423	136905	129442	126963	116437	116557	114799
E_{ig} (people)	1731	1590	1628	1755	1811	1734	1623	1575
GR_t (%)		-8.15	2.39	7.80	3.19	-4.25	-6.40	-2.96
$GR_{t=0}$ (%)		-8.15	-5.95	1.39	4.62	0.17	-6.24	-9.01
Number of stars	1	1	1	1	1	1	1	2
LQ	2.36	2.13	2.41	2.76	2.97	3.20	3.06	3.15
Size (%)	1.17	1.04	1.19	1.36	1.43	1.49	1.39	1.37
Focus (%)	0.74	0.70	0.72	0.78	0.82	0.82	0.79	0.81

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Paper Products cluster parameters								
E_i (people)	137015	136152	137499	136273	132216	128119	125839	130471
E_{ig} (people)	7794	7279	7156	7067	6501	5910	5604	5583
GR_t (%)		-6.61	-1.69	-1.24	-8.01	-9.09	-5.18	-0.37
$GR_{t=0}$ (%)		-6.61	-8.19	-9.33	-16.59	-24.17	-28.10	-28.37
Number of stars	3	3	3	3	3	3	3	3
LQ	11.51	10.94	10.56	10.56	10.24	9.92	9.78	9.83
Size (%)	5.69	5.35	5.20	5.19	4.92	4.61	4.45	4.28
Focus (%)	3.33	3.19	3.16	3.13	2.95	2.80	2.73	2.89
Furniture cluster parameters								
E_i (people)	314686	316139	294371	298059	294375	278843	267375	259033
E_{ig} (people)	2439	2329	1991	1809	1603	1418	1426	1431
GR_t (%)		-4.51	-14.51	-9.14	-11.39	-11.54	0.56	0.35
$GR_{t=0}$ (%)		-4.51	-18.37	-25.83	-34.28	-41.86	-41.53	-41.33
Number of stars	1	1	1	0	0	0	0	0
LQ	1.57	1.51	1.37	1.24	1.13	1.09	1.17	1.27
Size (%)	0.78	0.74	0.68	0.61	0.54	0.51	0.53	0.55
Focus (%)	1.04	1.02	0.88	0.80	0.73	0.67	0.69	0.74

Source: Employment statistics were obtained from: (HSE, 2018), (Federal State Statistics Service, 2019), (MinComSvyaz, 2019)
Calculations were performed by authors.

The Republic of Karelia had a high specialization level in Paper Products and the critical mass of its cluster was strongly decreasing during the period of 2009–2016. The overall decrease of the cluster's critical mass was 28.37% over eight years. In addition, the decrease of the Paper Products cluster's critical mass in the Republic of Karelia was significantly higher than the overall decrease of the Paper Products cluster's critical mass, being 27.61% compared to 4.78%. It led to a decrease in the cluster localization parameters, but it did not result in losing the specialization, since three localization measures out of three fulfilled the threshold requirements.

The Republic of Karelia lost specialization in Furniture Production in 2012, since the cluster's critical mass decreased by 41.33% over eight years, while the cluster's overall critical mass went down by only 17.69%. The breakpoint was in 2011–2012, when LQ did not fulfill the threshold requirements, along with Focus and Size.

Therefore, the Republic of Karelia was highly specialized only in one type of activity—Paper Products. However, the critical mass of this cluster greatly decreased during the analyzed period. In addition, the region had a low specialization in two other types of activities: Transportation and Logistics, which showed a decrease of the critical mass, and Maritime, the critical mass of which was unstable. In one type of activity, the region showed lack of specialization due to the continuously steady decrease in its critical mass.

Krasnoyarsk Krai cluster specialization analysis

The overall employment dynamic in Krasnoyarsk Krai was negative. The total number of employed people decreased by 6.15%, or by 64,833 people over eight years. Analyzing the employment statistics in Krasnoyarsk Krai during the period of 2009–2016, we detected four clusters: Transportation and Logistics, Business Services, and Entertainment and Production Technology, which received at least one star. Detailed results are presented in Table 8.

Krasnoyarsk Krai had a low specialization level in Transportation and Logistics. However, the critical mass of this cluster was stable during the analyzed period. In the long-term, the critical mass of the cluster increased by 0.87%; that is, by 782 people employed. In addition, the overall employment in the Transportation and Logistics cluster decreased by 5.2%. In total, it resulted in a slight increase of the relative localization measures of this

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cluster. However, it was not enough for significant strengthening of the regional specialization in this type of activity.

Table 8. Employment-based parameters of significant clusters in Krasnoyarsk Krai

Year / Parameter	2009	2010	2011	2012	2013	2014	2015	2016
General employment parameters								
E (people)	47427502	46719007	45872388	45898382	45815640	45486400	45106533	44446352
E_g (people)	1054055	1056537	1049084	1056420	1042109	1046767	1021040	989222
Transportation and Logistics cluster parameters								
E_i (people)	3489740	3370683	3371228	3400956	3360962	3377649	3352174	3308218
E_{ig} (people)	89985	88687	89832	91984	91829	92266	91374	90767
GR_t (%)		-1.44	1.29	2.40	-0.17	0.48	-0.97	-0.66
$GR_{t=0}$ (%)		-1.44	-0.17	2.22	2.05	2.53	1.54	0.87
Number of stars	1	1	1	1	1	1	1	1
LQ	1.16	1.16	1.17	1.18	1.20	1.19	1.20	1.23
Size (%)	2.58	2.63	2.66	2.70	2.73	2.73	2.73	2.74
Focus (%)	8.54	8.39	8.56	8.71	8.81	8.81	8.95	9.18
Business Services cluster parameters								
E_i (people)	2969478	2921201	2880799	3146203.9	3237312	3272631.1	3257275.3	3189467
E_{ig} (people)	74557	73045	75263	83302	83352	86755	81563	74253
GR_t (%)		-2.03	3.04	10.68	0.06	4.08	-5.98	-8.96
$GR_{t=0}$ (%)		-2.03	0.95	11.73	11.80	16.36	9.40	-0.41
Number of stars	0	0	0	1	0	1	0	0
LQ	1.13	1.11	1.14	1.15	1.13	1.15	1.11	1.05
Size (%)	2.51	2.50	2.61	2.65	2.57	2.65	2.50	2.33
Focus (%)	7.07	6.91	7.17	7.89	8.00	8.29	7.99	7.51
Entertainment cluster parameters								
E_i (people)	1134931	1096820	1076443	1087827.8	1067113.6	1027259	1014388	1010873
E_{ig} (people)	28162	28338	29061	29185	29604	29723	29290	28870
GR_t (%)		0.62	2.55	0.43	1.44	0.40	-1.46	-1.43
$GR_{t=0}$ (%)		0.62	3.19	3.63	5.12	5.54	4.01	2.51
Number of stars	1	1	1	1	1	1	2	2
LQ	1.12	1.14	1.18	1.17	1.22	1.26	1.28	1.28
Size (%)	2.48	2.58	2.70	2.68	2.77	2.89	2.89	2.86
Focus (%)	2.67	2.68	2.77	2.76	2.84	2.84	2.87	2.92
Production Technology cluster parameters								
E_i (people)	630556	608180	619596	614537	602202	587375.7	571254	545333
E_{ig} (people)	20539	20599	19981	20140	19771	19170	19031	19658
GR_t (%)		0.29	-3.00	0.80	-1.83	-3.04	-0.73	3.29
$GR_{t=0}$ (%)		0.29	-2.72	-1.94	-3.74	-6.67	-7.34	-4.29
Number of stars	1	2	1	1	1	1	2	2
LQ	1.47	1.50	1.41	1.42	1.44	1.42	1.47	1.62
Size (%)	3.26	3.39	3.22	3.28	3.28	3.26	3.33	3.60
Focus (%)	1.95	1.95	1.90	1.91	1.90	1.83	1.86	1.99

Source: Employment statistics were obtained from: (HSE, 2018), (Federal State Statistics Service, 2019), (MinComSvyaz, 2019)
Calculations were performed by authors.

The specialization of Krasnoyarsk Krai in Business Services was detected in 2012 and 2014, when a sudden increase in employment levels resulted in a growth of the Business Services cluster localization. However, it was a short-term increase which did not allow the region to strengthen its specialization over a long-term period. Therefore, the long-term decrease of the cluster's critical mass in Krasnoyarsk Krai was 0.41%.

Krasnoyarsk Krai had low specialization in Entertainment activities, which demonstrated a stable critical mass. In the long term, the critical mass of the Entertainment cluster grew by 2.51%; that is, 708 people. However, during

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the analyzed period there was a growth stage—from 2009 to 2014, the critical mass increased by 5.54%—and a decrease stage—from 2014 to 2016, it decreased by 2.87%. In addition, the overall employment in the Entertainment cluster decreased by 10.93%; that is, by 124,058 people employed. Due to this situation, the relative specialization of the region in Entertainment increased during 2015–2016 from one to two stars, since two of the three localization measures fulfilled the threshold requirements.

Krasnoyarsk Krai had low specialization in Production Technology, which was demonstrated by the stable state of its critical mass. In the long term, the critical mass of the Production Technology cluster decreased by 4.29%; that is, by 881 people employed. Nevertheless, with the overall employment of the Production Technology cluster decreasing by 13.52% (i.e. by 85,223 people employed), the relative specialization of the region in this type of activity grew in 2015, since two of three localization parameters fulfilled the threshold values.

Therefore, Krasnoyarsk Krai did not have high specialization in any type of activity. However, there are three groups of activities in which this region had low specialization: Transportation and Logistics, Entertainment, and Production Technology. All three clusters demonstrated a stable condition of their critical mass. In Business Services, the region had no specialization, since the critical mass of this cluster was too low.

Arkhangelsk Oblast (including Nenets AO) cluster specialization analysis

The overall employment dynamic in Arkhangelsk Oblast was negative. The total number of people employed decreased by 11.44%, or by 50,660 people over eight years. Analyzing Arkhangelsk Oblast employment statistics during the period of 2009–2016, we detected four clusters: Transportation and Logistics, Maritime, Paper Products, and Furniture, which received at least one star. Detailed results are presented in Table 9.

Arkhangelsk Oblast had a medium specialization level in Transportation and Logistics, and the critical mass of this cluster was unstable during the analyzed period. The long-term decrease of the cluster's critical mass over eight years was 5.94%; that is, 4,392 people employed. However, the overall specialization of the region in this type of activity increased, since the employment of the whole cluster also decreased by 5.2%, or by 181,522 people employed.

Arkhangelsk Oblast had low specialization in Maritime. However, the critical mass of this cluster decreased by 31.68%, or by 1,195 people during the analyzed period. The decline of this cluster was faster at the regional level than at the country level, meaning that the region was losing both its relative and absolute specialization in this type of activity.

Arkhangelsk Oblast had a high specialization level in Paper Products, and the critical mass of its cluster was strongly decreasing during the period of 2009–2016. The overall decrease of the cluster's critical mass was 24.81%; that is, by 2,268 people employed over eight years. In addition, the decrease of the critical mass of the Paper Products cluster in Arkhangelsk Oblast was significantly higher than the overall decrease of the critical mass of the Paper Products cluster, being 24.81% compared to 4.78%. It resulted in Arkhangelsk Oblast losing specialization in this type of activity. However, it still had a certain margin of safety, since all three localization parameters fulfilled the threshold conditions.

Therefore, Arkhangelsk Oblast, in total, had clusters with decreasing critical mass, which resulted, in some cases, in a rise in relative specializations, but a decrease in absolute values.

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Table 9. Employment-based parameters of significant clusters in Arkhangelsk Oblast (including Nenets AO)

Parameter \ Year	2009	2010	2011	2012	2013	2014	2015	2016
General employment parameters								
E (people)	47427502	46719007	45872388	45898382	45815640	45486400	45106533	44446352
E_g (people)	442903	433931	436355	418786.1	409795	405572.6	399017	392243.2
Transportation and Logistics cluster parameters								
E_i (people)	3489740	3370683	3371228	3400956	3360962	3377649	3352174	3308218
E_{ig} (people)	73878	71412	72084	68609	67490	67275	68010	69486
GR_t (%)		-3.34	0.94	-4.82	-1.63	-0.32	1.09	2.17
$GR_{t=0}$ (%)		-3.34	-2.43	-7.13	-8.65	-8.94	-7.94	-5.94
Number of stars	2	2	2	2	2	2	2	2
LQ	2.27	2.28	2.25	2.21	2.25	2.23	2.29	2.38
Size (%)	2.12	2.12	2.14	2.02	2.01	1.99	2.03	2.10
Focus (%)	16.68	16.46	16.52	16.38	16.47	16.59	17.04	17.72
Maritime cluster parameters								
E_i (people)	148225	152423	136905	129441.6	126963	116436.8	116557	114799
E_{ig} (people)	3772	3802	3949	3701	3192	2568	2554	2577
GR_t (%)		0.80	3.87	-6.28	-13.75	-19.55	-0.55	0.90
$GR_{t=0}$ (%)		0.80	4.69	-1.88	-15.38	-31.92	-32.29	-31.68
Number of stars	1	1	1	2	1	1	1	1
LQ	2.73	2.69	3.03	3.13	2.81	2.47	2.48	2.54
Size (%)	2.54	2.49	2.88	2.86	2.51	2.21	2.19	2.24
Focus (%)	0.85	0.88	0.90	0.88	0.78	0.63	0.64	0.66
Paper Products cluster parameters								
E_i (people)	137015	136152	137499	136273	132216	128119	125839	130471
E_{ig} (people)	9141	8578	8548	8308	7778	7448	7012	6873
GR_t (%)		-6.16	-0.35	-2.81	-6.38	-4.24	-5.85	-1.98
$GR_{t=0}$ (%)		-6.16	-6.49	-9.11	-14.91	-18.52	-23.29	-24.81
Number of stars	3	3	3	3	3	3	3	3
LQ	7.14	6.78	6.54	6.68	6.58	6.52	6.30	5.97
Size (%)	6.67	6.30	6.22	6.10	5.88	5.81	5.57	5.27
Focus (%)	2.06	1.98	1.96	1.98	1.90	1.84	1.76	1.75
Furniture cluster parameters								
E_i (people)	314686	316139	294371	298059	294375	278843	267375	259033
E_{ig} (people)	5145	4776	4429	4122	3566	3450	3492	2935
GR_t (%)		-7.17	-7.27	-6.93	-13.49	-3.25	1.22	-15.95
$GR_{t=0}$ (%)		-7.17	-13.92	-19.88	-30.69	-32.94	-32.13	-42.95
Number of stars	1	1	1	0	0	0	0	0
LQ	1.75	1.63	1.58	1.52	1.35	1.39	1.48	1.28
Size (%)	1.63	1.51	1.50	1.38	1.21	1.24	1.31	1.13
Focus (%)	1.16	1.10	1.01	0.98	0.87	0.85	0.88	0.75

Source: Employment statistics were obtained from: (HSE, 2018), (Federal State Statistics Service, 2019), (MinComSvyaz, 2019)
Calculations were performed by authors.

Arkhangelsk Oblast lost specialization in Furniture Production in 2012, since the critical mass of the cluster in Arkhangelsk Oblast decreased by 42.95%; that is, by 2,210 people over eight years. Meanwhile, the overall critical mass of the cluster decreased by only 17.69%. The breakpoint was in 2011–2012, when LQ fulfilled neither of the threshold requirements, nor did Focus or Size.

Khanty-Mansi AO cluster specialization analysis

The overall employment dynamic in Khanty-Mansi AO was negative. The total number of people employed decreased by 2.18%, or by 16,772 people over eight years. Analyzing employment statistics in Khanty-Mansi AO

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during the period of 2009–2016, we detected three clusters: Transportation and Logistics, Oil and Gas, and Construction, which received at least one star. Detailed results are presented in Table 10.

Khanty-Mansi AO lost specialization in Furniture Production in 2010, since the cluster's critical mass decreased by 13.93%; that is, by 9617 people over eight years. Meanwhile, the cluster's overall critical mass decreased by only 5.2%. Therefore, the region was steadily losing its specialization in this type of activity due to the decrease of the cluster's critical mass.

Table 10. Employment-based parameters of significant clusters in Khanty-Mansi AO

Year / Parameter	2009	2010	2011	2012	2013	2014	2015	2016
General employment parameters								
E (people)	47427502	46719007	45872388	45898382	45815640	45486400	45106533	44446352
E_g (people)	770656	770048	771193	774807	771928	769370	761089	753884
Transportation and Logistics cluster parameters								
E_i (people)	**3489740**	**3370683**	**3371228**	**3400956**	**3360962**	**3377649**	**3352174**	**3308218**
E_{ig} (people)	69030	68126	65137	64990	64567	61782	59825	59413
GR_t (%)		-1.31	-4.39	-0.23	-0.65	-4.31	-3.17	-0.69
$GR_{t=0}$ (%)		-1.31	-5.64	-5.85	-6.47	-10.50	-13.33	-13.93
Number of stars	0	1	0	0	0	0	0	0
LQ	1.22	1.23	1.15	1.13	1.14	1.08	1.06	1.06
Size (%)	1.98	2.02	1.93	1.91	1.92	1.83	1.78	1.80
Focus (%)	8.96	8.85	8.45	8.39	8.36	8.03	7.86	7.88
Oil and Gas cluster parameters								
E_i (people)	504955	504478	517301	536739	556754	578881	594546	606641
E_{ig} (people)	119572	121334	124170	129379	134175	139619	146402	150665
GR_t (%)		1.47	2.34	4.20	3.71	4.06	4.86	2.91
$GR_{t=0}$ (%)		1.47	3.85	8.20	12.21	16.77	22.44	26.00
Number of stars	3	3	3	3	3	3	3	3
LQ	14.57	14.59	14.28	14.28	14.30	14.26	14.59	14.64
Size (%)	23.68	24.05	24.00	24.10	24.10	24.12	24.62	24.84
Focus (%)	15.52	15.76	16.10	16.70	17.38	18.15	19.24	19.99
Construction cluster parameters								
E_i (people)	3425797	3430749	3163493	3254308	3225983	3123938	2983398	2800194
E_{ig} (people)	93202	93124	87788	87179	80821	77105	72677	68966
GR_t (%)		-0.08	-5.73	-0.69	-7.29	-4.60	-5.74	-5.11
$GR_{t=0}$ (%)		-0.08	-5.81	-6.46	-13.28	-17.27	-22.02	-26.00
Number of stars	2	3	3	2	2	2	2	2
LQ	1.67	1.65	1.65	1.59	1.49	1.46	1.44	1.45
Size (%)	2.72	2.71	2.78	2.68	2.51	2.47	2.44	2.46
Focus (%)	12.09	12.09	11.38	11.25	10.47	10.02	9.55	9.15

Source: Employment statistics were obtained from: (HSE, 2018), (Federal State Statistics Service, 2019), (MinComSvyaz, 2019)
Calculations were performed by authors.

Khanty-Mansi AO had a high specialization level in Oil and Gas, and the critical mass of this cluster was growing significantly during the analyzed period. The overall increase of the cluster's critical mass was 26% over eight years. This resulted in the strengthening of the cluster's specialization and its stabilization at a high level, since three localization measures out of three fulfilled the threshold requirements.

Khanty-Mansi AO had a medium specialization level in Construction and the critical mass of this cluster was greatly decreasing during the analyzed period. The long-term decrease of the cluster's critical mass was 26%, or 24,236 people employed. Nevertheless, the specialization of Khanty-Mansi AO in Construction remains at a high level, despite the fact that it is constantly decreasing.

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We identified three clusters in Khanty-Mansi AO: Transportation and Logistics, Oil and Gas, and Construction. Only the Oil and Gas cluster showed strong growth of its critical mass, while the other two clusters were decreasing in terms of the number of people employed.

Murmansk Oblast cluster specialization analysis

The overall employment dynamic in Murmansk Oblast was negative. The total number of people employed decreased by 11.11%, or by 34,409 people employed over eight years. Analyzing employment statistics in Murmansk Oblast during the period of 2009–2016, we detected two clusters: Transportation and Logistics and Maritime, which have received at least one star. Detailed results are presented in Table 11.

Table 11. Employment-based parameters of significant clusters in Murmansk Oblast

Parameter \ Year	2009	2010	2011	2012	2013	2014	2015	2016
General employment parameters								
E (people)	47427502	46719007	45872388	45898382	45815640	45486400	45106533	44446352
E_g (people)	309727	301079	300264	300209	296615	288905	281950	275318
Transportation and logistics cluster parameters								
E_i (people)	3489740	3370683	3371228	3400956	3360962	3377649	3352174	3308218
E_{ig} (people)	47243	44929	42501	41274	40302	38585	37209	36936
GR_t (%)		-4.90	-5.40	-2.89	-2.35	-4.26	-3.57	-0.73
$GR_{t=0}$ (%)		-4.90	-10.04	-12.63	-14.69	-18.33	-21.24	-21.82
Number of stars	2	2	2	2	2	2	2	2
LQ	2.07	2.07	1.93	1.86	1.85	1.80	1.78	1.80
Size (%)	1.35	1.33	1.26	1.21	1.20	1.14	1.11	1.12
Focus (%)	15.25	14.92	14.15	13.75	13.59	13.36	13.20	13.42
Maritime cluster parameters								
E_i (people)	148225	152423	136905	129441.6	126963	116436.8	116557	114799
E_{ig} (people)	8734	8016	7464	7834	7466	7170	6832	6321
GR_t (%)		-8.22	-6.89	4.96	-4.70	-3.96	-4.71	-7.48
$GR_{t=0}$ (%)		-8.22	-14.54	-10.30	-14.52	-17.91	-21.78	-27.63
Number of stars	3	3	3	3	3	3	3	3
LQ	9.02	8.16	8.33	9.25	9.08	9.70	9.38	8.89
Size (%)	5.89	5.26	5.45	6.05	5.88	6.16	5.86	5.51
Focus (%)	2.82	2.66	2.49	2.61	2.52	2.48	2.42	2.30

Source: Employment statistics were obtained from: (HSE, 2018), (Federal State Statistics Service, 2019), (MinComSvyaz, 2019) Calculations were performed by authors.

Murmansk Oblast had a medium specialization level in Transportation and Logistics, and the critical mass of this cluster was steadily decreasing during the analyzed period. The overall decrease of the critical mass of the Transportation and Logistics cluster located in Murmansk Oblast was 21.82%; that is, 10,307 people employed over eight years. Therefore, all three localization parameters of the cluster decreased. Nevertheless, its specialization remains at the level of two stars.

Murmansk Oblast had a high specialization level in Maritime, and the critical mass of its cluster was steadily decreasing during the period of 2009–2016. The overall decrease of the cluster's critical mass was 27.63% over eight years. In addition, the decrease of the Maritime cluster's critical mass in Murmansk Oblast was higher than the overall decrease of the Maritime cluster's critical mass, being 27.63% compared to 22.55%. It resulted in Murmansk Oblast decreasing in overall specialization in this type of activity in the long run.

Therefore, there are only two significant clusters in the Murmansk region: Transportation and Logistics and Maritime. The critical masses of both clusters were steadily decreasing during the analyzed period. Consequently,

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the region lost its specialization and should promote new core activities, which can be part of its long-term development.

Sakha Republic cluster specialization analysis

The overall employment dynamic in Sakha Republic was negative. The total number of people employed decreased by 6.22%, or by 22,722 people employed over eight years. Analyzing the employment statistics in Sakha Republic during the period of 2009–2016, we detected two clusters: Entertainment and Oil and Gas, which have received at least one star. Detailed results are presented in Table 12.

Sakha Republic had not had a specialization level in Oil and Gas until 2011. Due to a significant growth of the cluster's critical mass over a long-term period of 3,535 people employed, or 83.65%, one of the localization parameters fulfilled the threshold requirement and the region received one star in this type of activity. Therefore, the region has a potential for strengthening its specialization if the critical mass continues to grow.

Table 12. Employment-based parameters of significant clusters in Sakha Republic

Parameter \ Year	2009	2010	2011	2012	2013	2014	2015	2016
General employment parameters								
E (people)	47427502	46719007	45872388	45898382	45815640	45486400	45106533	44446352
E_g (people)	365340	353047	355669	354493	351108	348962	344686	342618
Oil and Gas cluster parameters								
E_i (people)	504955	504478	517301	536739	556754	578881	594546	606641
E_{ig} (people)	4226	3836	6529	7120	7043	7209	7313	7761
GR_t (%)		-9.23	70.20	9.05	-1.08	2.36	1.44	6.13
$GR_{t=0}$ (%)		-9.23	54.50	68.48	66.66	70.59	73.05	83.65
Number of stars	0	0	1	1	1	1	1	1
LQ	1.09	1.01	1.63	1.72	1.65	1.62	1.61	1.66
Size (%)	0.84	0.76	1.26	1.33	1.27	1.25	1.23	1.28
Focus (%)	1.16	1.09	1.84	2.01	2.01	2.07	2.12	2.27
Entertainment cluster parameters								
E_i (people)	1134931	1096820	1076443	1087827.8	1067113.6	1027259	1014388	1010873
E_{ig} (people)	12374	12200	12150	12571.8	12340.6	12059	11995	11942
GR_t (%)		-1.41	-0.41	3.47	-1.84	-2.28	-0.53	-0.44
$GR_{t=0}$ (%)		-1.41	-1.81	1.60	-0.27	-2.55	-3.06	-3.49
Number of stars	1	1	1	1	1	1	1	1
LQ	1.42	1.47	1.46	1.50	1.51	1.53	1.55	1.53
Size (%)	1.09	1.11	1.13	1.16	1.16	1.17	1.18	1.18
Focus (%)	3.39	3.46	3.42	3.55	3.51	3.46	3.48	3.49

Source: Employment statistics were obtained from: (HSE, 2018), (Federal State Statistics Service, 2019), (MinComSvyaz, 2019) Calculations were performed by authors.

Sakha Republic had a low specialization in Entertainment; the critical mass of this cluster was at a stable level. The long-term change of the critical mass was negative. It declined by 3.49%, or 432 people over eight years.

Therefore, Sakha Republic has a potential for strengthening its specialization in Oil and Gas and Entertainment activities.

Chukotka AO cluster specialization analysis

The overall employment dynamics in Chukotka AO was negative. The total number of people employed decreased by 9.72%, or by 2,946 people employed over eight years. Analyzing the employment statistics in

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Chukotka AO during the period of 2009–2016, we did not detected any clusters which could receive at least one star. The general results of the employment dynamics are presented in Table 13.

Table 13. Employment-based parameters of significant clusters in Chukotka AO

Parameter \ Year	2009	2010	2011	2012	2013	2014	2015	2016
Genera employment parameters								
E (people)	47427502	46719007	45872388	45898382	45815640	45486400	45106533	44446352
E_g (people)	30300	30055	29914	29494	28983	27902	27758	27354
Employment statistics were obtained from: (HSE, 2018), (Federal State Statistics Service, 2019), (MinComSvyaz, 2019)								

Source: Combined results of the Russian regions cluster parameters analysis

Combined results of the Russian regions cluster parameters analysis

Table 14 gives an analytical interpretation of the computational results presented earlier. The table includes only those clusters which were significant in at least in one Arctic region. Therefore, nine clusters out of 37 are presented. Boxes with the symbol «-» in Table 14 refer to the unidentified (insignificant) clusters. We did not mark them in order to make it clearer for analysis. Other boxes include the characteristic of the cluster in a specific region in accordance with the classification, presented in Section 2.1.

Table 14. State of development of identified clusters in Russian arctic regions for 2009–2016

Cluster \ Region	Komi Republic	Yamalo-Nenets AO	Republic of Karelia	Krasnoyarsk Krai	Arkhangelsk Oblast including Nenets AO	Khanty-Mansi AO	Murmansk Oblast	Sakha Republic	Chukotka AO
Transportation and Logistics	Medium spec./ Unstable	Medium spec./ Unstable	Low spec./ Strong decrease	Low spec./ Stable	Medium spec./ Unstable	No spec./ Strong decrease	Medium spec./ Strong decrease	-	-
Maritime	-	Low spec./ Strong decrease	Low spec./ Unstable	-	Low spec./ Strong decrease	-	High spec./ Strong decrease	-	-
Oil and Gas	High spec./ Strong growth	High spec./ Strong growth	-	-	-	High spec./ Strong growth	-	No spec./ Strong growth	-
Paper products	High spec./ Strong decrease	-	High spec./ Strong decrease	-	High spec./ Strong decrease	-	-	-	-
Business services	No spec./ Strong decrease	No spec./ Strong growth	-	No spec./ Unstable	-	-	-	-	-
Construction	No spec./ Unstable	Medium spec./ Unstable	-	-	-	Medium spec./ Strong decrease	-	-	-
Entertainment	-	-	-	Low spec./ Stable	-	-	-	Low spec./ Stable	-
Furniture	-	-	No spec./ Strong decrease	-	No spec./ Strong decrease	-	-	-	-

Information Technologies	-	-	-	-	-	-	-	-	-
Tourism	-	-	-	-	-	-	-	-	-
Production Technology	-	-	-	Low spec./ Stable	-	-	-	-	-

Source: The table is constructed based on the results presented in section 2 methodology implementation. Detailed results are presented in Section 3. Abbreviation «Spec.» refers to the term «Specialization. Symbol «-» refers to the situation, when a cluster's critical mass is too low, i.e. it is now identified in the region. The first line each box presents the evaluation result of region specialization in types of activities performed by a cluster i in the region g. (see Table 2 for more details).The second line refers to the type of dynamic state of employment of cluster i in region g. (see Table 3 for more details).

Tables 14 and 15 provide some valuable insights concerning the overall situation in the Russian Arctic regions.

The first insight is that the overall state of the most typical significant clusters for these regions is not satisfactory, since there is only one significant cluster which achieved a steady growth. We can see that, in general, employment in such clusters as «Transportation and Logistics», «Maritime», «Paper Products», «Construction», «Entertainment», and «Furniture» was mostly either decreasing or unstable, which means that these clusters were steadily declining in a long term perspective during the analyzed period. On the other hand, the only significant cluster which achieved a steady growth in all regions where it was present was the «Oil and Gas» cluster.

Table 15. Cross-matrix of the state of development of the clusters in Russian Regions for 2009–2016

Level of region specialization / **Dynamic state of employment**	**High specialization**	**Medium specialization**	**Low specialization**	**No specialization**
Strong employment growth	Oil and Gas (3)	-	-	Oil and Gas (1) Business Services (1)
Moderate employment growth	-	-	-	-
Stable employment level	-	-	Transportation and Logistics (1) Entertainment (2) Production technology (1)	-
Unstable employment growth	-	Transportation and Logistics (3) Construction (1)	Maritime (1)	Business Services (1) Construction (1)
Moderate decrease in employment	-	-	-	-
Strong decrease in employment	Paper products (3) Maritime (1)	Transportation and Logistics (1) Construction (1)	Transportation and Logistics (1) Maritime (2)	Transportation and Logistics (1) Business Services (1) Furniture (2)

Numbers in brackets reflect the number of regions where the cluster is present.

Source: Compiled by Authors

The second insight refers to the overall cluster structure of the Russian Arctic region. A majority of clusters in Russian Arctic regions are not significant, meaning that there are relatively too few employees. Therefore, the localization of these clusters is slightly above average, which is not enough for generating positive spillovers or organizing export activities.

These two insights can potentially become a basis for elaborating a policy which will slow down the decrease of the discussed clusters and, consequently, support diversification and specialization of the economy, since it is associated with positive spillover effects.

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Discussion and conclusion

This research study provides several results, which contribute both to practical and theoretical fields.

First, we present the architecture of the database for automated identification of clusters in the Russian regions. This architecture can be used for creating any other database to calculate cluster localization parameters in any other country or region.

Secondly, we, in brief, present methodology for cluster identification and discuss how clusters can be identified from the perspective of the European Cluster Observatory. We complement this methodology through presenting two additional dimensions, which can be used for better interpretation and systematization of results. The dimension «Level of region specialization» depends on the average number of stars obtained by a certain cluster in a certain region. The dimension «Dynamic state of employment» represents the pattern of employment change during the analyzed period.

Thirdly, we present the main results for cluster identification using the example of the Russian Arctic regions. It is stated that most of the significant clusters are decreasing, while the only cluster which achieved steady growth in terms of localization parameters was «Oil and Gas». The obtained results allowed us to conclude that the cluster structure of the Russian Arctic regions is poor in the sense that there are few significant clusters and that most of them are weak and decreasing. This result can be used as a basis for elaborating regional economic policy to support regional diversification and specialization.

There are also several opportunities for further research. Firstly, the presented database can be modified in order to provide results, which are more valuable. Currently it calculates only four parameters, which reflect localization parameters and regional specialization. It can be expanded in order to calculate more metrics, which are based not only on employment data, but also on salary and sales data of the clusters. In addition, functions can be included to compose indexes based on several parameters. In addition, it could be interesting to tackle the technical issues connected with data input. At the moment, before data are input to the database, a big job has to be done, which is connected to acquiring and formatting data. If it were possible to connect the database directly to the State Statistical Service systems, the time spent waiting to receive a result would significantly decrease.

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Conceptualization, A.S., T.K., M.A.B.; Methodology, T.K.; Validation, A.S. and T.K.; Formal Analysis, A.S.; Investigation, A.S. and T.K.; Data Curation, A.S.; Writing-Original Draft Preparation, A.S., T.K., M.A.B.; Writing-Review & Editing, T.K., M.A.B.; Visualization, A.S.; Supervision, T.K.; Project Administration, T.K.; Funding Acquisition, T.K.

Conflicts of Interest

The authors declare no conflict of interest.

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An empirical study of information technology clusters and regional economic growth in Russia

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Abstract. The paper is devoted to the identification of the "Information Technologies" cluster in the regions of the Russian Federation and verification of the assumption that there is an interaction between the degree of cluster representation in the region and the GRP size. The authors considered the main theoretical and methodological provisions concerning the identification of clusters with the Top-down approach. Based on the develops of M. Porter and G. Lindqvist, the "Information Technologies" cluster characteristics such as local content, size and focus were calculated for 80 regions of the Russian Federation. The conclusions about the specifics of the cluster development in the country were made. Using the methods of regression analysis, the authors tested a number of hypotheses and revealed the presence of a positive interaction between the GRP volume and the "Information Technologies" cluster presence in the regions of the Russian Federation, as well as the local content, size and focus of this cluster in the regions of the Russian Federation.

1 Introduction

Regional economic growth is a relevant studies trend [1]. Issues related to the relationship between the economic growth and development of information technologies in separate countries and regions are also the subject of many scientific studies [2, 3, 4, 5, 6]. In particular, in terms of the development and institutionalization of the concepts "digital economy" [7, 8] and "sixth technological mode" [9] which is based on the convergence of nanotechnologies, biotechnologies, information technologies and cognitive science, the authors deem that it is advisable to perform an empirical study on the analysis of information technologies cluster development in the regions of the Russian Federation and the identification of the relationship between its characteristics and regional economic growth.

The information technologies are one of the drivers of economical growth in the modern world. Mainly, the studies related to the assessment of ICT effect on the economical growth at the national level are divided into two large categories. The first category includes the studies which reflect ICT interest bearing deposit to GDP growth. For example, the studies of M. Timmer, G. Ypma & B. Van Ark [10], D. Jorgenson & K. Vu [12] et al. The second group includes the studies using the cross-country methods of regression analysis to assess the ICT effect on the economical growth. This category include studies of Z. Latif, S. Latif,

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L. Ximei, Z. H. Pathan, S. Salam, & Z. Jianqiu [13], T. Niebel [14], et al. In this case, the studies of the second group are usually devoted to two problems:

- assessment of the impact of investments in ICT on the economic growth of the regions;
- assessment of the impact of technologies penetration and distribution, their level of use on economic growth.

In this case, the problem of the influence of the cluster structure considered from the perspective of the macro level and, in particular, the ICT cluster on the economic growth of the regions remains open and little presented in the literature.

Thus, the study purpose is to find the relationship between the regional economic growth and the development of the "Information Technologies" cluster in the Russian Federation. To achieve this goal, the authors revealed the main theoretical and methodological provisions related to the identification of clusters using the top-down approach, estimated the local content, size and focus of the cluster group "Information Technologies" in 80 regions of the Russian Federation in the period from 2008 to 2016, marked the significant clusters and built four groups of regression models reflecting the positive relationship between the development of the "Information Technology" cluster and the real GRP growth in the region.

2 Cluster and its identification

One of the key aspects of the cluster theory is the problem of clusters identification within separate territories – regions. As foreign experience shows, the existing methodological approaches with a low variety of tools differ considerably in practice. There are many pairs of categories for characterizing the process and techniques for clusters identification, however, most of them are based on two main approaches [15]. In the first approach that can be called "down", the clusters are identified in a specific area based on the presence of enterprises and industries-leaders known in advance. The second approach uses a technique conventionally called "top" where spatially localized industries oriented to the specific types of economic activity are detected. Further, to detect and perform initial analysis of specific regional clusters, a nationwide reference sample is used.

The meaning of "reference" clusters is to determine the types of economic activity which are most often located near each other, and, therefore, have the effect of complementarity. Since "the degree to which the industries actually colocalized in the space indicates the importance of local inter-industry contacts" [16], if spatial affinity is between two or more industries, it will serve to synergy the cluster specialization industries.

The approaches to identification of clusters "top", taking into account two invariable characteristics of clusters – functional connectivity and geographical proximity – are conventionally divided into 2 types: 1) functional, focused on detection of certain types of the clusters;2) spatial, focused on detection of the geographic clusters.

It is now generally recognized that the best results of identification of the clusters "top" are achieved through a combination of functional and spatial approaches. Such synthetic approaches include the approach of M. Porter. The M. Porter's method became classic and one of the most widespread in other countries. Many European and a few domestic attempts to identify and map the clusters do not just use the Harvard approach as the technique, but are based on its results.

As a result of numerous studies, M. Porter was able to fully determine the structure of "reference" clusters based on the variety of activities represented in the American Classifier SIC (Standard Industrial Classification) [17].

Subsequently, the "reference" cores of the cluster groups were widely used by the US Department of Commerce, which supports the project of US clusters mapping [18]. The composition of the "reference" cluster core was adapted for the European Union taking into

account the application of the European NACE classifier in the project of the European cluster observatory for identification and mapping of economic agglomerations of the EU countries [19].

Full adaptation of foreign Standard Industrial Classification to the Russian analogue – OKVED has not been carried out to date.

The solution of this problem by adapting the structure of the "reference" cluster cores for the Russian economy in accordance with the Standard Industrial Classification OKVED will allow determining the composition of the most probable cores of cluster groups of RF entities and can be widely used as an adequate basis for approbation of foreign methods of cluster analysis.

3 Top – down approach for cluster identification

In the framework of the "top" approach, the filling of cluster groups within the territory of the federation entities in accordance with the identified "standards" allows to form conditional clusters, but the clusters identification suggests confirmation of the hypothesis of their existence within the specified territory that can be achieved with the use of statistical tools in accordance with the methodology proposed by the European cluster observatory [19].

The presence and development of positive economic externalities affecting the activities of enterprises included in the cluster is determined by the presence of a certain "critical mass" of the cluster group core. As a consequence, the formed "reference" cores of the cluster groups shall be investigated for the presence of specified "critical mass" that determines the relative strength and competitiveness of the local cluster.

This method is based on the assumption that the volume and qualitative level of knowledge circulating between enterprises and organizations included in the cluster under investigation depends on the cluster size, its specialization level, and the extent to which the studied region is aimed at products production in related areas included in the cluster. These 3 factors are determined by the European cluster observatory as the "Localization Coefficient" (1), "Size" (2), "Focus" (3). The factor values within the threshold values reflect whether the studied cluster has achieved a sufficient "critical mass" to generate the positive external effects and relations. These indicators are calculated according to the employment statistics and are specified in the following formula:

$$LQ = \frac{Emp_{ig}}{Emp_g} / \frac{Emp_i}{Emp} \quad (1)$$

where LQ is the "localization coefficient"; Emp_{ig} is a number of employees in the cluster group i in region g; Emp_g is the total number of employees in the region g; Emp_i is a number of employees in the cluster group i; Emp is the total number of employees.

$$Size = \frac{Emp_{ig}}{Emp_i} \quad (2)$$

where Size is the "Cluster group size"; Emp_{ig} is a number of employees in the cluster group i in region g; Emp_i is a number of employees in the cluster group i.

$$Focus = \frac{Emp_{ig}}{Emp_g} \quad (3)$$

where Focus is the cluster group "focus"; Emp_{ig} – is a number of employees in the cluster group i in region g; Emp_g is a number of employees in the region g.

G. Lindqvist, a Swedish economist from the European Cluster Observatory [20] sets the following criteria as the threshold values that feature the meaningful cluster groups in the region:

1) "Localization coefficient" (3.1) ≥ 2;

2) the region shall be among the 10% of the regions leading by "Size" (3.2);

3) the region shall be among the 10% of the regions leading by "Focus" (3.2);

Fulfillment of the constraint conditions for each indicator means assignment of a "star" to the cluster group 1. Thus, as much as possible, one or another cluster group can receive 3 "stars". A number of "stars" determines cluster group strength.

In addition, none of the "stars" can be assigned if the total number of workers in the cluster core does not exceed 1000 persons.

As a result, the implementation of the described methodology makes it possible to obtain data on a number and strength of the studied cluster groups in all regions of the studied country (group of countries).

It should be noted that the restriction by the "Localization coefficient" is a variable value. Thus, M. Porter, when studying the "core" of clusters (i.e., the clusters in the strict sense), determined the threshold value of the localization coefficient at 1.0 [17], and the US Department of Commerce uses the threshold value 1.3 [18]. In our study, when selecting the strong clusters, it is proposed to use a threshold value of 1.3.

Thus, in the course of the cluster analysis, adaptation of the results of the synthetic approach to the Russian economy makes it possible to identify the cluster "standards" typical for the studied area, and the use of the European Cluster Observatory criteria makes it possible, firstly, according to employment statistics, to check the hypothesis of a specific cluster groups strength in one region or another by a number of assigned "stars", and secondly, to identify the regions where the studied clusters are significant. The identification of such regions allows speaking both of the existence of interterritorial clusters, which accounting allows for a more effective regional policy, and the existence of competing "centers" of concentration of relevant industries capable of "draining" the employment of other cluster groups through the action of more significant positive agglomeration externalities within their territory.

The application of criteria for the level of cluster groups' development makes it possible to identify strong clusters within the country and its regions, but does not provide sufficient information about the factors of the cluster geographical concentration – agglomeration external effects which determine a level and potential of cluster group development within the studied territory.

4 The results of assessment of the "Information Technologies" cluster development in the regions of the Russian Federation in the period from 2008 to 2016

To assess the development of the "Information Technologies" cluster in the regions of the Russian Federation, the authors compared the activities according to the NACE classifier, which M. Porter assigns to the "Information Technologies" cluster with the corresponding activities according to the OKVED-2001 classifier (see Table 1).

Table 1. Correlation of activity types included in the "Information Technology" cluster according to the NACE and OKVED-2001 classifiers.

Cluster	Activities according to NACE (Europe)		Activities according to OKVED (Russia)	
Information Technology	26.20	Manufacture of computers and peripheral equipment	30.0	Production of office equipment and computer technologies
	58.21 58.29 62.01	Publishing of computer games; Other software publishing; Computer programming activities	72.20	Software development and consulting in this field

Further, the authors calculated a level of localization, size and focus of this cluster for 80 regions of the Russian Federation for the period from 2008 to 2016 and identified 13 regions, where at least once per this period a cluster was identified in accordance with the criteria presented above. The calculation results for Moscow and St. Petersburg are presented in Fig. 1.

As of 2016, the "Information Technologies" cluster is represented in the following regions (see Table 2): St. Petersburg, Moscow, Yaroslavl Region, Novosibirsk Region, Tatarstan and Penza Region. The cluster is the largest in Moscow and St. Petersburg – 30.52% and 16.14% of all persons employed in the cluster in the Russian Federation, in this case, the cluster focus – a share of persons employed in the cluster in relation to all ones in the region – in Moscow it is increased from 0.96% to 1.2%, and in St. Petersburg – from 0.58% to 1.47%. High cluster localization in these cities with relatively small values of focus and size is explained by the higher population in them and by the fact that they are the main administrative, managerial and economic centers of the country.

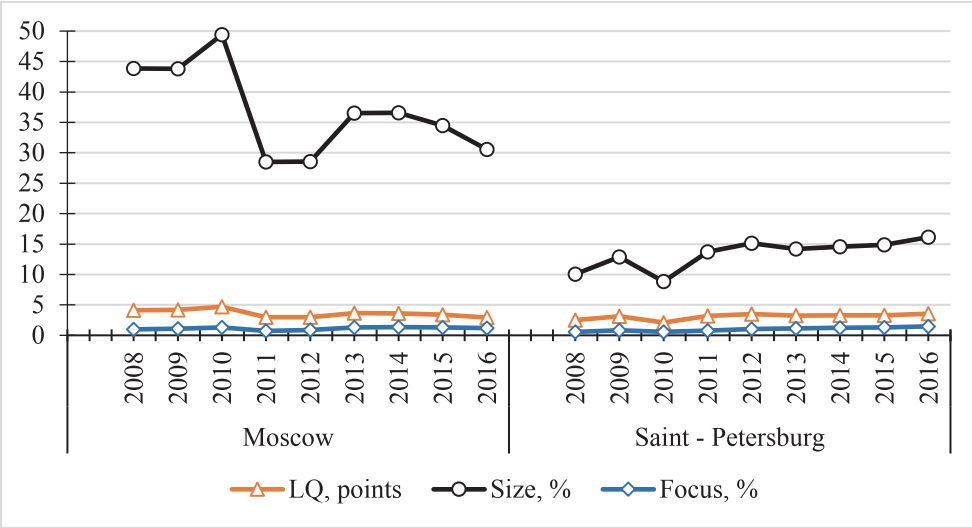

Fig. 1. Dynamics of changes in the level of localization, size and focus of the"Information Technologies" cluster in Moscow and St. Petersburg.

Table 2. A number of stars assigned to the "Information Technology" cluster in some regions of Russian Federation.

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Republic of Bashkortostan	2	1	2	3	1	1	1	0	0
Republic of Tatarstan	1	1	1	1	1	1	2	2	3
Khabarovsk Territory	0	0	0	2	2	1	0	0	0
Vladimir Region	0	0	3	0	0	0	0	0	0
Kaluga Region	2	1	0	0	0	0	0	0	0
Novosibirsk Region	3	1	0	3	3	3	3	3	3
Penza Region	2	2	2	2	2	2	2	2	2
Perm Territory	0	0	0	0	1	0	1	2	0
Yaroslavl Region	0	1	1	2	2	2	2	2	2
Kursk Region	3	2	0	0	0	0	0	0	0
Nizhny Novgorod Region	2	2	2	3	3	2	2	1	1
Moscow	3	3	3	3	3	3	3	3	3
Saint Petersburg	3	3	3	3	3	3	3	3	3

In the period from 2008 to 2016, a stable growth of indicators characterizing the cluster development occurred only in two regions: St. Petersburg and the Republic of Tatarstan. So, in St. Petersburg, the growth of the level of the localization (ELQ) for nine years was 1.05 units, the size (ESize) by 6.09 percentage points and the focus (EFocus) by 0.89 percentage points. In Tatarstan, the level of localization increased by 0.71 units, the focus – by 0.43 percentage points, and the size by 2.24 percentage points. The simultaneous increase in all three indicators reflects the increase in specialization of these regions on the "Information Technologies".

As well as the stable presence of the "Information Technologies" cluster is observed in the Penza and Novosibirsk regions although the dynamics of its development in these regions is not unambiguous. Thus, in the Penza region there is cluster weakening over the past nine years for all three indicators. While in Novosibirsk region, despite the general trend to its

increasing, the cluster development dynamics is characterized by constant downturns and upturns.

5 The relationship between the regional economic growth and the development of the "Information Technologies" cluster in the Russian Federation.

5.1 Model, hypothesis and study method

The relationship between the regional economic growth and the development of the "Information Technology" cluster in the Russian Federation was measured using the regression analysis tools available in the STATA MP14 program.The basic study tool was the Linear regression with panel-corrected standard errors proposed by Beck and Katz as an alternative to the feasible generalized least squares (FGLS) based algorithm proposed by Parks and Kmenta in 1986 [21, 22].

In the framework of this study, 12 models were built and tested, in the framework of which the presence or absence of relationship between the characteristics of the "Information Technologies" cluster and the GRP size was assessed. These models are divided into 4 groups depending on the hypotheses to be tested.

The first group of models can be represented as an equation as follows:

$$\ln GRP_{it} = \beta_0 + \beta_1 \ln RIiFA_{it} + \beta_2 \ln TRE_{it} + \Upsilon_i ClusterIT_{it} + \phi_t Year_t + \varepsilon_{it} + U_t \quad (4)$$

where:
$\ln GRP_{it}$ −base logarithm of GRP (rub., in constant prices of 2008) generated in region i at time t;
$\ln RIiFA_{it}$ −base logarithm of investments (rub., in constant prices of 2000) in the fixed capital carried out in region i at time t;
$\ln TRE_{it}$- base logarithm of a number of workers employed in the region (million persons) in region i at time t;
$ClusterIT_{it}$- a binary variable that takes the value 1 if there is an "Information technology" cluster in the region, and otherwise, it is 0.
$Year_t$ − binary variables that take the value 1 if the observation refers to a certain year t, and otherwise, it is 0.

For dependent and independent control variables to graduate heteroscedasticity resulting from the uneven social and economic position of the regions, the functional form of the basic logarithm was taken. In addition, the logarithmic specification of the regression equation made it possible to linearize the presented function by analogy with the Cobb-Douglas production function, which allows interpreting their coefficients as elasticity.

The H1 hypothesis is tested in the framework of the first group of models, according to which there is a statistically significant relationship between the GRP volume and the presence of the "Information Technologies" cluster in the region.

The second, third and fourth groups of models were constructed by analogy with the first one:

$$\ln GRP_{it} = \beta_0 + \beta_1 \ln RIiFA_{it} + \beta_2 \ln TRE_{it} + \Upsilon_i LQ_{it} + \phi_t Year_t + \varepsilon_{it} + U_t \quad (5)$$

$$\ln GRP_{it} = \beta_0 + \beta_1 \ln RIiFA_{it} + \beta_2 \ln TRE_{it} + \Upsilon_i Size_{it} + \phi_t Year_t + \varepsilon_{it} + U_t \quad (6)$$

$$\ln GRP_{it} = \beta_0 + \beta_1 \ln RIiFA_{it} + \beta_2 \ln TRE_{it} + \Upsilon_i Focus_{it} + \phi_t Year_t + \varepsilon_{it} + U_t \quad (7)$$

where:

LQ_{it}- the value of the localization coefficient of the "Information technology" cluster in region i at time t;
$Size_{it}$ – the size of the cluster group i at time t, %;
$Focus_{it}$ – the focus of the cluster group i at time t, %.

In the second model the H2 hypothesis of statistically significant relationship between the localization level of the "Information Technology" cluster in the region and with the GRP volume, the third – the H3 hypothesis of the presence of positive relationship between the size of the"Information Technology" cluster in the region and with the GRP volume, the fourth – the H4 hypothesis on the presence of positive relationship between the focus of the"Information Technology" cluster in the region and with the GRP volume.

In groups of models 2, 3 and 4, the indexes: 1 corresponds to the models built based on 80 regions of the Russian Federation, 2 – based on 13 regions, where the minimum required value for two parameters of three was achieved at least once per 2008 – 2016 according to the "Information Technology" cluster, 3 – based on 13 regions with an adjustment for annual fixed effects.

5.2 Empirical results of the study

The main empirical results of the study are presented in the Appendix. Based on these calculations, we can conclude that there is an interaction between GRP volumes and the main characteristics of the "Information Technology" cluster (see Tables 3 and 4).

So, according to the results of models 1.1 – 1.3, there is a statistically significant interaction between the GRP volume and the cluster presence in the region. That is, in regions, where the presence of this cluster is recorded, the GRP level is higher on average (hypothesis H1 is confirmed).

Models 2.1 – 2.3 show the presence of positive interaction between the level of local content of the "Information Technologies" cluster in the region and the GRP volume. That is, in regions, where the employment level in the "Information Technologies" cluster is higher, the GRP level is higher on average (hypothesis H2 is confirmed).

Models 3.1 – 3.3 show the presence of positive interaction between the size of the "Information Technology" cluster in the region and the GRP volume. That is, in regions, where the employment share in the "Information Technologies" cluster is more relative to everybody employed in the region, the GRP level is higher on average (hypothesis H3 is confirmed).

Models 4.1 – 4.3 show the presence of positive interaction between the focus of the "Information Technology" cluster in the region and the GRP volume. That is, in regions, where the employment share in the "Information Technologies"cluster is more relative to everybody employed in the region, the GRP level is higher on average (hypothesis H4 is confirmed).

In this case, these interactions are maintained even when we control in the models the volumes of investment in fixed assets by organizations, manpower in the region and annual fixed effects.

Table 3. Empirical results of the estimation relationship between "Information technology" cluster characteristics and Gross regional product (models 1 and 2).

MODELS / VARIABLES	Model 1			Model 2		
	1.1	1.2	1.3	2.1	2.2	2.3
Whether cluster "Information technologies" presented in the region or not	**1.290*** ** (0.144)	**0.153*** ** (0.0265)	**0.152*** ** (0.0265)			
LQ				**0.930*** ** (0.0417)	**0.0999*** ** (0.0207)	**0.104*** ** (0.0189)
Natural logarithm of real investments in fixed assets		0.720*** (0.0293)	0.725*** (0.0284)		0.476*** (0.0536)	0.474*** (0.0489)
Natural logarithm of total regional employment		0.345*** (0.0343)	0.340*** (0.0337)		0.821*** (0.0784)	0.820*** (0.0724)
Constant	12.13*** (0.0297)	4.500*** (0.332)	4.356*** (0.328)	11.73*** (0.0277)	7.179*** (0.624)	7.104*** (0.571)
Observations	640	640	640	640	104	104
R-squared	0.104	0.944	0.948	0.266	0.971	0.976
NumberofRegionID	80	80	80	80	13	13
Year FE	No	No	Yes	No	No	Yes
chi2	79.94	34153	35068	496.1	3765	3791
rmse	1.052	0.262	0.256	0.952	0.184	0.174

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4. Empirical results of the estimation relationship between «Information technology» cluster characteristics and Gross regional product (models 3 and 4).

MODELS / VARIABLES	Model 3			Model 4		
	3.1	3.2	3.3	4.1	4.2	4.3
Size	**0.0271*****	**0.0217*****	**0.0222*****			
	(0.00176)	(0.00141)	(0.00137)			
Focus				**0.584*****	**0.351*****	**0.303*****
				(0.0504)	(0.0556)	(0.0668)
Natural logarithm of real investments in fixed assets		0.449***	0.435***		0.483***	0.469***
		(0.0484)	(0.0411)		(0.0489)	(0.0492)
Natural logarithm of total regional employment		0.699***	0.710***		0.804***	0.834***
		(0.0647)	(0.0576)		(0.0734)	(0.0762)
Constant	4.592***	7.564***	7.630***	4.334***	7.094***	7.205***
	(0.321)	(0.550)	(0.471)	(0.339)	(0.567)	(0.574)
Observations	640	104	104	640	104	104
R-squared	0.953	0.983	0.988	0.951	0.972	0.975
Number of Region ID	80	13	13	80	13	13
Year FE	No	No	Yes	No	No	Yes
chi2	47263	6055	6511	43222	2778	3128
rmse	0.242	0.142	0.123	0.247	0.180	0.178

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6 Conclusion

The relevance of measuring the impact of the information technology development on the GRP level is difficult to overestimate in the modern world. This work shows that the assessment of this contribution can be made from different sides including using macroeconomic data based on the cluster structure of the regions. Based on the theoretical and methodological developments of M. Porter and G. Lindqvist, the authors analyzed the main characteristics of the "Information Technology" cluster identified on the basis of employment data in the regions of the Russian Federation. Using the methods of econometric analysis, the authors have revealed the existence of positive interaction between the GRP volumes and the characteristics of the "Information Technologies" cluster based on the example of the regions in the Russian Federation. In this case, the positive significant interaction remained both in models built across all the regions and in models built around the regions where at least once in 2008 – 2016 the cluster existence was recorded.

It should be noted that the conclusions drawn under this study reflect the situation in the Russian Federation and the authors of future studies shall interpret these results with care when their extrapolation to other regions.

As guidelines for future studies, the authors consider it important to perform a more detailed examination of the «Information Technologies" cluster and its impact on GRP of the regions. In particular, in addition to the characteristics of the cluster based on the employment

level, the assessment aspects Jacobian proximity effects and "Marshallian" proximity effects and their interaction to GRP volumes in the regions are relevant.

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Research of Cluster Structure in Regions of Russia (Case Study: St. Petersburg)

Tatiana Jurievna Kudryavtseva

Abstract The purpose of this study is to analyze the regional cluster structure of the Russian economy. To achieve this goal the following things were done. The cluster groups' kernels structure, which had been developed by the European cluster observatory, was adapted for the Russian economy. Statistical databases were created with the number of employees and number of companies for the regions of the Russian Federation over the period of 2008–2012. The geographical concentration of cluster groups was assessed. The cluster groups developed in the Russian regions, for example in St. Petersburg, were identified according to the European cluster observatory criteria. Detection of positive agglomerative effects of concentration or urbanization in advanced cluster groups of the region allows assessing the innovative potential of the region development. The results of the study can be used to substantiate actions following the regional cluster policy.

Keywords Regional economy of Russia • Cluster groups • Geographical concentration • Urbanization • Localization • Regional cluster policy

1 Introduction

Russian literature has been focusing a lot on examining clusters as specific forms of inter-organizational cooperation between economic agents (Andreev and Naumova 2012; Kharlamova 2012; Vorobyev and Lipatnikov 2012; Babkin et al. 2011). This growing interest of the Russian scientific community has been supported by governmental initiatives aimed at developing regional clusters as forms of industrial engineering that boost innovative activities.

After it was analyzed the cluster policy of St. Petersburg was characterized as sector, technological and innovative, focused on supporting the largest and advanced industrial sectors and, in addition, as tactic, aimed at funding the private sector or, in the context of federal special purpose programs with poor regional

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financing, and concentrated on supporting the few strong and stable regional clusters. The analysis has revealed that an important element of efficiency of such a policy is to assess objectively how strong and stable are the clusters that the regional government bodies are developing through application of scientifically grounded methods and identification of the cluster groups in the region.

The purpose of this paper is to analyze the cluster structure of the federal subjects of Russia (regions of Russia), i.e., to identify regions, localization of different cluster groups and do comparative research of agglomeration externalities resulting from collocation of enterprises belonging to different clusters in the regions of Russia, for example St. Petersburg.

2 Methodology

A cluster is a specific form of agglomeration of enterprises which directly entails appearance of specific agglomeration externalities, i.e., proximity effects that are caused by collocation of enterprises. Agglomeration and agglomeration externalities are inter-influencing but at the same time independent phenomena.

High geographical concentration of enterprises in the same industry, which is also called localization, is a sign of industrial specialization of an area and can be defined by the degree of the employment non-uniformity in a certain industry by regions in comparison with, for example, the general number of population or working people. This type of concentration strengthens "Marshallian" proximity effects, i.e., concentration effects.

Uneven general agglomeration clearly shows intensity of economic activities in a region and is called urbanization. This type of concentration encourages "Jacobian" proximity effects, i.e., urbanization effects caused by concentration of any industrial companies in a certain area.

Geographical concentration localizes and increases proximity effects, such as, for example, labor resources mobility, efficient use of existing skills and development of new ones. Proximity effects, in their turn, boost and support geographical concentration and, thus, make areas where they are distributed economically attractive (Lindqvist 2009).

The cluster theory, developed by Porter (2005), is intermediate in between "Marshallian" and "Jacobian" proximity effects While "Marshallian" effects show result of geographical concentration of enterprises in the same industry and "Jacobian" effects reflect agglomeration externalities, related to co-localization of enterprises involved in different lines of business in a certain area, the concept of a cluster implies considering companies that operate in inter-related and complementary industries (Simmie 2013). The inter-industry nature of clusters is one of the key distinctions of this type of enterprises' agglomeration in comparison with other agglomeration forms.

The localization coefficient, which is used as the most common measurement of geographical concentration to identify and analyze cluster groups, does not help to make a judgment about factors causing collocation of enterprises. At the same time,

decomposition of Ripley's K-function by concentration and urbanization indices, presented in Lindqvist (2009), allows selecting factors encouraging geographical concentration of clusters.

Concentration index (Conc) shows the degree of attraction to collocate for enterprises of a certain cluster group in comparison with the degree of attraction to co-localize for companies involved in all sorts of business. If the index value is more than 1, it signals that these enterprises are prone to collocation, which implies a positive economic effect from concentration for the enterprises in this cluster.

The urbanization index (Urb) demonstrates the degree of attraction between the enterprises of a certain cluster group to co-localize with enterprises involved in all sorts of business in comparison with the degree of attraction between enterprises involved in all sorts of business to collocate with each other. Thus, if the index degree is more than 1, it means that the enterprises in the cluster under examination have a tendency to be located in areas with high density of enterprises operating in all sorts of business, which, again, implies positive effects from urbanization for the enterprises in this cluster group.

Values of concentration and urbanization indices depend on the selected distance value in terms of which the trend for collocation of enterprises is studied. The distance in terms of which this trend is looked into can vary depending on the purpose of the analysis. The key issue of this paper is to define the proneness of cluster enterprises to collocate within the limits of one subject of the Russian Federation. A federal subject has been chosen as a unit of territorial division because a cluster is seen, first of all, as an innovation-oriented form of enterprises' agglomeration. Innovative policy is normally implemented at the regional level since distribution of non-formalized knowledge, which can only be obtained through social interaction and is, at the same time, a major factor contributing to innovation, is limited by a region, in accordance with empirical research (Lindqvist 2009; Gerben 2004). As a result, the transformed formulae have the following form:

$$Urb = \frac{\frac{1}{\sum_{j=1}^{N} n_{ij} \sum_{j=1}^{N} n_{xj}} \sum_{j=1}^{N} n_{ij} n_{xj}}{\frac{1}{\sum_{j=1}^{N} n_{xj} \left(\sum_{j=1}^{N} n_{xj} - 1 \right)} \sum_{j=1}^{N} n_{xj} \left(n_{xj} - 1 \right)} \tag{1}$$

$$Conc = \frac{\frac{1}{\sum_{j=1}^{N} n_{ij} \left(\sum_{j=1}^{N} n_{ij} - 1 \right)} \sum_{j=1}^{N} n_{ij} \left(n_{ij} - 1 \right)}{\frac{1}{\sum_{j=1}^{N} n_{ij} \sum_{j=1}^{N} n_{xj}} \sum_{j=1}^{N} n_{ij} n_{xj}} \tag{2}$$

where N—is the number of federal subjects; n_{ij}—is the number of enterprises belonging to i-cluster in j-federal subject; n_{xj}—is the number of enterprises engaged in all sorts of business in j-federal subject.

Depending on the presence of positive or negative proximity effects from collocation with enterprises of an analogous cluster group (*Conc* is more or less than 1), and, also, from collocation with enterprises engaged in all sorts of business (*Urb* is more or less than 1), all clusters can be classified as concentrated or scattered, and urban or rural (Lindqvist 2009).

In order to research proximity effects from collocation of enterprises, belonging to various cluster groups, on the basis of statistics about the average number of workers within the limits of regions and on the basis of 4-digit OKVED codes (Russian Classification of Economic Activities). 36 cluster groups have been formed. In 2012 the total number of people working for the enterprises belonging to the cluster groups was 1974.87 thousand people for the Russian Federation (41 % of the national employment). When defining the industry contents of the cluster groups, the ECO methodology was used and matching between NACE rev.1 and OKVED classifier codes was done. It has to be mentioned that so as to avoid dual accounting of the employed or companies that may arise due to overlapping cluster groups, the object of the analysis is cluster kernels exceptionally, which implies referring each type of business activities to a single cluster only (Porter 2003).

In order to determine the geographical limits of the clusters in Russia and the regions of their localization, relative indices have been calculated, which characterize significance or strength of a cluster in the region and assess presence and development of positive economic effects influencing the companies included in a cluster. Thus, the ECO methodology implies that a cluster group is important in the region in case there is correspondence to two or more of the following criteria:

1. Localization coefficient ≥ 2;
2. The region belongs to 10 % regions, leading by Size;
3. The region belongs to 10 % regions, leading by Focus.

Rating formulae of indices are given in Lindqvist (2009). The threshold value of the localization coefficient is variable. Thus, Porter (2005) defined the threshold value of the localization coefficient at the level of 8.0–1.0 (Porter 2005) whereas U.S. Department of Commerce sets the threshold value equal to 1.3. Because of its nature, the localization index evaluates non-uniformity of the size distribution in a certain area. It is obvious that differences in defining the limits of the index are caused, first of all, by varying geographical features of Europe and America: thus, the average density of population in Europe is 72 people per km^2, whereas it is 32 people per km^2 in America. Owing to a vast territory and relatively low density of population equal to 8.2 people per km^2, economic geography of Russia is more similar to America rather than to Europe, which is why we use the value 1.3 when identifying significant clusters of a region in our study. Moreover, a cluster group of a region cannot be recognized as significant if the total number of people working in this group is fewer than 1000 people.

The revealed complex of important clusters localized in a certain region forms the cluster structure of this region. The research results of St. Petersburg's cluster structure are presented below.

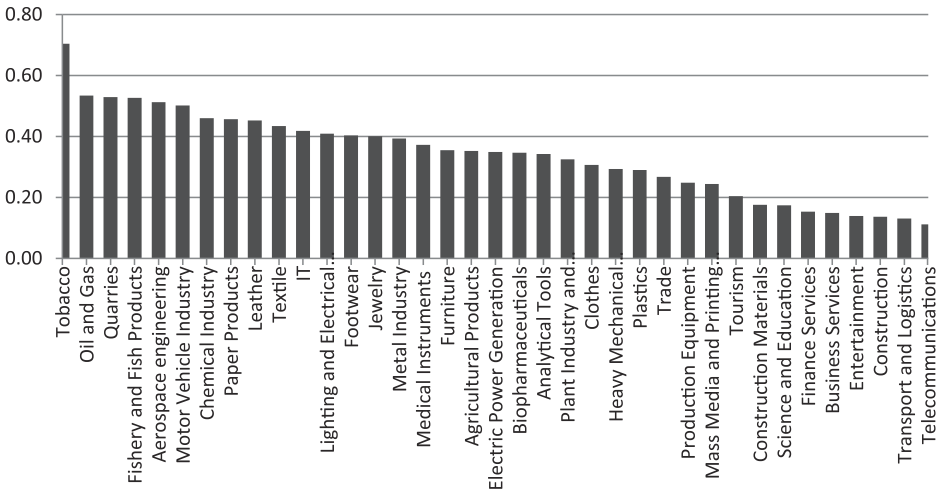

Fig. 1 Level of non-uniformity in distribution of the number of employees in clusters by federal subjects of Russia (agglomeration coefficient value) at the average in 2008–2012

3 Results

On the basis of the statistics about the number of enterprises and organizations by areas and types of economic activities in 2012, agglomeration, concentration and urbanization indices have been calculated for each cluster group (Fig. 1 and Table 1). With the analysis of the employment statistics by the ECO methodology, strong cluster groups of subjects of the Russian Federation have been discovered. The calculations have been worked out by the ECO methodology for all subjects of the Russian Federation for 2008–2012. Table 2 includes a fragment of the calculation results for the important clusters of St. Petersburg.

Analysis of the cluster structure of the St. Petersburg economy led to the following conclusions. As a result of defining the list of important clusters of the region and on the basis of the data on overlapping clusters by related industries set by M. Porter (2003), a map of overlapping for the important clusters of St. Petersburg has been created. Table 2 and Fig. 2 demonstrate that 8 important clusters of St. Petersburg have been identified: “Information Technology”, “Science and Education”, “Trade”, “Biopharmaceuticals”, “Lighting and Electrical Equipment”, “Electric Power Generation and Transmission”, “Finance Services”, “Analytical Tools”. These ones account for the cluster structure of St. Petersburg that is represented in Fig. 2.

A comparative analysis of the cluster structure of the St. Petersburg economy in comparison with other regions led to the following conclusions.

The region accommodates a majority of cluster groups with a high degree of urbanization and concentration, namely: Biopharmaceuticals, Information Technology, Science and Education, Finance Services, etc. (see Table 1). The enterprises of these clusters belong to concentrated cluster groups of the city and

Table 1 Concentration and urbanization of cluster groups in Russia in 2012

Cluster group	Conc	Urb	Cluster group	Conc	Urb
Information technology	2.02	1.81	Analytical tools	1.09	0.98
Science and education	1.92	1.74	Aerospace engineering	1.05	0.8
Entertainment	1.79	1.62	Lighting and electrical equipment	1.03	0.99
Mass media and printing industry	1.74	1.59	Construction	1.02	1.01
Finance services	1.68	1.53	Plastics	1.02	0.75
Oil and gas	1.61	0.76	Chemical industry	0.96	0.83
Fishery and fish products	1.61	0.35	Production equipment	0.95	0.89
Business services	1.55	1.47	Heavy mechanical engineering	0.92	0.9
Telecommunications	1.53	1.44	Paper products	0.92	0.81
Biopharmaceuticals	1.52	1.36	Metal industry	0.92	0.69
Medical instruments	1.4	1.34	Electric power generation and transmission	0.91	0.78
Trade	1.38	1.33	Tourism	0.9	0,85
Plant industry and animal production	1.37	0.28	Clothes	0.89	0.79
Quarries	1.33	0.44	Agricultural products	0.89	0.58
Textile	1.28	0.84	Construction materials	0.88	0.63
Jewelry	1.17	1.06	Footwear	0.86	0.65
Tobacco	1.13	0.79	Transport and logistics	0.84	0.76
Leather	1.11	1.05	Furniture	0.82	0.67
Motor vehicle industry	1.11	0.7			

experience considerable positive proximity effects due to being located so close both to each other and to the enterprises engaged in any other lines of business. These cluster groups have a high potential to develop in big cities or federal subjects with high density of population and significant economic activity.

So the cluster “Biopharmaceuticals” correspond to two and more strength criteria in St. Petersburg, Kursk Oblast, Moskow Oblast, Tula Oblast, Kurgan Oblast and Penza Oblast, Republic of Tatarstan. St. Petersburg ranks No. 3 in terms of the number of the employed in the cluster Biopharmaceuticals, falling behind only Moscow and Moscow Oblast. In 2010 there started a program of the governmental support of the St. Petersburg pharmaceutical cluster, which was later expanded to the pharmaceutical and medical industry cluster with the purpose to help create, produce and bring into use innovative medical products, generic drugs and medical equipment. Indirect evidence, proving efficiency of these measures, is the growing number of workers in this cluster in St. Petersburg, which has increased by 11 %, with the total number of people employed in this industry falling by 16 % countrywide.

The dynamically developing cluster “Information Technology” demonstrated the biggest value of the localization coefficient in Moscow. This region employed most people in this sector (35.6 % of the total number of the employed in the

Table 2 Results of identifying the cluster groups of St. Petersburg in 2008–2012

	Localization coefficient					Focus (rank)					Size (rank)				
	2008	2009	2010	2011	2012	2008	2009	2010	2011	2012	2008	2009	2010	2011	2012
Analytical tools	1.29	1.65	1.38	1.57	1.41	24	16	22	17	22	3	1	1	1	2
Biopharmaceuticals	1.49	1.40	2.09	1.65	1.86	13	13	9	12	12	3	3	3	3	3
Information technology	2.48	3.12	2.10	3.20	3.17	3	2	2	1	2	2	2	2	2	2
Science and education	1.96	1.98	1.93	2.02	2.01	1	1	1	1	1	2	2	2	2	2
Lighting and electrical equipment	1.48	1.48	1.77	1.77	2.22	18	16	15	16	10	3	3	2	1	1
Electric power generation and transmission	1.49	1.46	1.67	1.34	1.59	20	19	16	22	19	3	2	2	3	2
Trade	1.85	1.89	1.88	1.79	1.47	4	3	3	3	3	2	2	2	2	2
Finance services	1.15	1.10	1.06	1.08	1.09	4	5	5	4	4	2	2	2	2	2

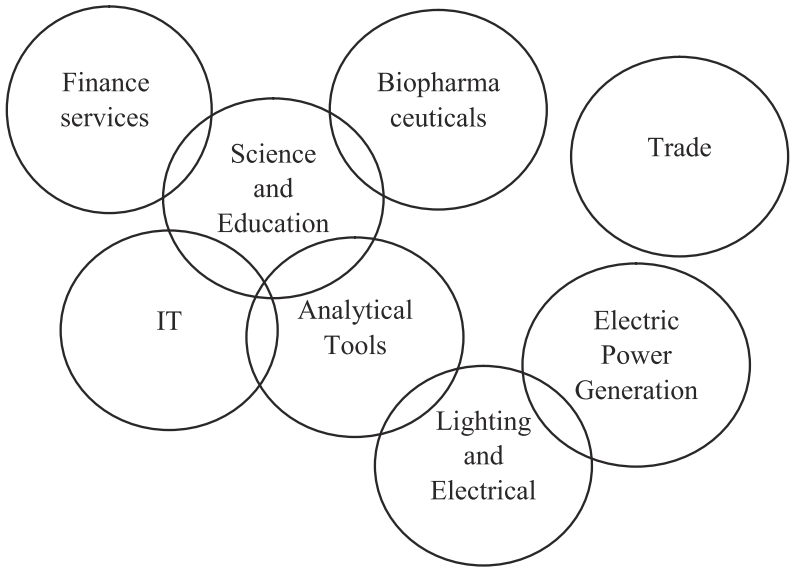

Fig. 2 Map of important overlapping clusters in St. Petersburg

Information Technology cluster all over Russia) in 2012. However, the growth dynamics of the St. Petersburg cluster is significantly bigger than that of the Moscow cluster both in absolute and relative indices. Thus, the number of workers in the cluster rose by 76 % in St. Petersburg while in Moscow it grew only by 5 % over 2007–2012.

St. Petersburg is one of the country leaders in terms of the total number of workers in the cluster group "Analytical Tools" giving way only to Moscow. It is worth specific mentioning that in 2006 a special economic zone of the technology implementation type was created, which is meant to encourage entrepreneurship by a number of businesses that include precision and analytical instrument industry and belong to the cluster "Analytical Tools". Residents of this zone are provided with tax and customs incentives, and have opportunities to follow a simplified procedure so as to obtain a plot of land and have favorable rent conditions. In 2008 the St. Petersburg Association of Enterprises of Radioelectronics, Instrument Engineering, Means of Communication and Infotelecommunications was set up. It has been used as a basis of the St. Petersburg innovation territorial cluster of radioelectronics, instrument engineering, means of communication and infotelecommunication, which obtains governmental support through a number of federal grant programs. Undoubtedly this entails additional positive economic effects caused by the location of the enterprises belonging to the cluster industries in St. Petersburg.

The cluster "Science and Education" is one of the most common clusters in Russia and features an extremely high degree of concentration and urbanization with a rather low agglomeration value at the same time (see Table 1 and Fig. 1). The low value of the agglomeration coefficient means that enterprises of this industry

are widely spread in Russia. The high urbanization level is confirmed with a clear strength of the cluster "Science and Education" in the densely populated federal subjects of Russia with high economic activity. Absolute leaders in terms of the importance of this cluster are Moscow, St. Petersburg and Moscow Oblast. Most people employed in the cluster "Science and Education" work in Moscow. However, in relative terms, the share of people working in this cluster from the total number of employed is higher in St. Petersburg than in Moscow (9.37 % and 8.75 % respectively). St. Petersburg is one of the biggest scientific and educational centers in Russia and has more than 350 scientific organizations including 70 organizations of the Academy of Sciences of the Russian Federation and other state academies, 56 public and 45 private institutions of higher education. Among them there are many leading universities that train specialists in natural, technical and humanitarian sciences. Revealingly, with general fall in the number of the cluster group in Russia by 7 %, the cluster "Science and Education" of St. Petersburg demonstrates a slight growth in employment.

It has to be said that in accordance with the overlapping defined by Porter (2003), the cluster "Science and Education" has the biggest influence on such cluster groups as "Biopharmaceuticals", "Analytical Tools", "Information Technology". Thus, the strength of the cluster group "Science and Education" considerably contributes to developing a number of other science-driven cluster groups in St. Petersburg.

Production of lighting and electrical equipment in Russia is represented by strong clusters in several federal subjects, including St. Petersburg, Smolensk Oblast, Tver Oblast, Tula Oblast, Chelyabinsk Oblast, Republics of Mordovia, Chuvashia and Mari El. The cluster "Lighting and Electrical Equipment" holds the leading countrywide position in St. Petersburg. Its number grew by almost a quarter over the period under review and was 9528 people in 2012.

The cluster "Electric Power Generation and Transmission" corresponds to 2 and more criteria of importance in a number of federal subjects, which include St. Petersburg, Pskovsk Oblast, Kursk Oblast, Kirovsk Oblast, Penza Oblast, Samara Oblast, Saratov Oblast and the Republic of Udmurtia. St. Petersburg holds the second position in Russia after Moscow in terms of the number of workers in the cluster" Electric Power Generation and Transmission", although the number of people working here fell by 9 % over the 5 year period. In St. Petersburg there are several key enterprises producing electrical machinery and equipment for thermal, nuclear, hydraulic and gas-turbine power plants. Moreover, a distinctive feature of some enterprises in St. Petersburg, belonging to the cluster "Electric Power Generation and Transmission", is the fact that they operate as research and production enterprises and associations.

The biggest share of the cluster group kernel "Trade" is taken by wholesale trade, since the core activities of retail business account for local industries. A distinctive feature of the Russian cluster "Trade" is its strong concentration in the capital city with relatively low presence in other regions. Thus, 26.73 % of all the workers in the cluster group were employed in Moscow in 2012. The second largest cluster group "Trade" is located in St. Petersburg. Nevertheless, its size is 4 times smaller than that of Moscow and takes 6.32 % of all the people working in the

cluster group in all federal subjects. Although the size of the cluster group "Trade" is diminishing both in Moscow and in St. Petersburg, the rate of drawdown in St. Petersburg exceeds that of the cluster in the capital city.

The cluster group "Finance Services" is marked by a low agglomeration coefficient (0.15), (see Fig. 1) which says for quite a uniform distribution of the number of workers by federal subjects of Russia. Financial market of St. Petersburg is the second largest regional financial market of Russia. However, it is falling behind remarkably. Thus, the total number of people working in this cluster in St. Petersburg is 5 times smaller comparing to the same cluster in Moscow and takes just 4.71 % of the total number of those employed in the cluster group industries throughout Russia. Nevertheless, the development level of the city financial infrastructure is quite high: 45 commercial banks, more than 100 branches of banks from other regions and over 400 financial and brokerage companies are registered in St. Petersburg.

It has to be said that from 8 important cluster groups 7 ones, consistent with the "wide" definition of the cluster, overlap each other, according to M. Porter (Fig. 2). Since in this research cluster "kernels" are studied, it excludes any possibilities of direct influence of the overlapping cluster groups on the strength level of each other through inclusion of industries that belong to the kernels of other clusters and components of the overlapping groups. However, almost 90 % of the important cluster groups in St. Petersburg overlap each other. Correspondingly, it can be assumed that this is caused by positive proximity effects in this region.

Thus, it can be concluded that the economy of St. Petersburg has a unique cluster structure that is based on tight interaction between science and production. St. Petersburg is a centre of localization for science-driven and high-tech cluster groups that have high concentration and urbanization levels and, correspondingly, are prone to be located in big cities.

4 Discussion

Comparison of the research results of the cluster structure of St. Petersburg and the federal and regional industrial development programs has revealed that the following meaningful clusters in the region are actively supported by the government: "Information Technology", "Biopharmaceuticals", "Lighting and Electrical Equipment", "Electric Power Generation and Transmission", "Analytical Tools". At the same time there are no development programs for the following important cluster groups: Science and Education", "Trade", "Finance Services". However, the Committee on Industry and Innovation Development of St. Petersburg implements the development programs of car-making and ship-building clusters whose enterprises are weakly localized in the region.

Today the literature includes active debates about the degree and ability of government to affect the economy when applying the tools of industrial policy (Hospers et al. 2009; Kaplina 2013; Babkin et al. 2013). We agree with the idea that

the ability of government to create and develop clusters of industrial enterprises is extremely limited. The major risk when implementing cluster policy is the wrongly chosen subject of research since there is information asymmetry, lack of statistic data and no effective tools for revealing clusters and their prototypes. Governmental policy focused on supporting the traditional and well-established enterprises in a certain region partly solves social problems of the regions, but at the same time makes worse the competitive environment, which is the basic factor for appearance and development of a cluster. On the other hand, when hi-tech industries are supported there are also risks caused by the lack of institutional infrastructure in the region which patterns after successful inter-related industries and enterprises of other regions. In this context, in St. Petersburg there is no program for developing the cluster "Science and Education", which is infrastructural for all the hi-tech clusters, such as: "Information Technology", "Biopharmaceuticals", "Analytical Tools". As a result there are problems related to personnel and the chain from development of a product to development of production equipment is broken. However, positive effects from development programs of the high-tech clusters in the region are also there since localization of such enterprises in St. Petersburg grew over years 2008–2012 (see Table 2).

5 Conclusion

As a result of seeing into the theories of Porter (2003, 2005) and Lindqvist (2009), one can conclude that a cluster is a specific form of agglomeration of enterprises, which, correspondingly, entails specific agglomeration externalities, including both concentration and urbanization effects. Identification of the regions where clusters localize, analysis of positive proximity effects from concentration and urbanization of a cluster group helps to evaluate a potential for development of a region and can be used to assess efficiency of measures of regional cluster policy.

These methods have made it possible to define the important clusters of St. Petersburg's economy. Thus, it can be concluded that the economy of St. Petersburg has a unique cluster structure that is based on tight interaction between science and production. St. Petersburg is a centre of localization for science-driven and high-tech cluster groups that have high concentration and urbanization levels and, correspondingly, are prone to be located in big cities.

The major target of the further research is in-depth study of the condition and dynamics of certain cluster groups developed in St. Petersburg so as to justify the need for regional cluster policy measures and increase the efficiency of state investments in the development of the cluster structure of the region.

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(ETIS Classification 3.1)

Methodical Bases of Identification and Ranking of Developed Cluster Groups of Regional Economy (Case Study: St. Petersburg)

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Abstract

The article presents the results of industry cluster structure research of the St. Petersburg economy. There were found significant cluster groups, which include "Biopharmaceutical", "Trade", "Information Technology", "Scientific research". "Analytical Tools", "Communication equipment", "Plastic", "Leather", "Aerospace". All clusters are evaluated from the point of view of uniqueness, coherence and economic effectiveness for the level of wages criteria, profits and investments. Group "Biopharmaceuticals", "Analytical tools" and "Communication equipment" are the most unique in the city, i.e. they are poorly represented or absent in other regions of the North-West Federal District. Cluster "Biopharmaceuticals" leads by the connectivity index with other cluster groups in the region and enterprises of the cluster are characterized by the maximum level of profits, wages and investments.

Keywords: Clusters, the cluster group, localization, economic effectiveness, the region's economy

Introduction

This article describes the results of the algorithm study testing of the regional economy cluster structure, formed on the basis of a synthesis of research results M. Portera, the European Cluster Observatory and Russian scientists.

Clusters, as a tool to increase the competitiveness of the region are considered in the scientific works of M. Porter (2003), O. Solvell, G. Lindqvist and K. Ketels (2003), M. Enright, M.-P. Menzel, D. Fornahla, E. Bergman, E. Feser. In clusters' research the following Russian scientists are engaged: LS Markov, V.M. Markova, G.B. Kleiner, A.V. Babkin (2013; 2014), E.E. Immodest, I.V. Pilipenko, V.P. Tretiak, D.V. Grushevskii, A.Y. Yudanov, A.Y. Skopin, S.M. Kadochnikov, P.V. Vorobiev, E.S. Kutsenko (2014), D.G. Rodionov (2014), Zaborovskaia O.V. and others.

However, despite the large number of papers on this topic, the problem of an innovative economy building through the creation and development of clusters is still barely developed. One of the key issues of the clusters' theory is the problem of the identification. International experience shows, that existing methodological approaches with low diversity of tools vary considerably in practice. You can point out many techniques to identify clusters, but most of them are based on two main approaches. In the first, which can be called "from beneath", the clusters are identified in specifically selected areas, based on the presence of previously known enterprises and industries leaders. The second approach uses a technique conventionally called "from above" where spatial localization of enterprises are sought, which are pointed to specific kinds of economic activities.

Approaches for identifying clusters "from above" traditionally divided into two types: 1) functional, oriented at an identification of industrial clusters; 2) spatial, oriented at an identification of geographical clusters.

Now it is generally accepted that the best results of identifying clusters "from above" is achieved through a combination of industrial and spatial approaches. These approaches include a synthetic approach of M. Porter (Harvard Business School) (2003). The M. Porter method became a classic and one of the most widely used in other countries. Many European and a few local attempts of an identification and mapping of the clusters do not just use the Harvard approach as a technique, but are based on its results; followers of his methodology are scientists of the European Cluster Observatory and Russian scientists (Lindqvist, 2009; Solvell, Lindqvist and Ketels, 2003; Kiselev, Kutcenko and Karnaukh, 2014).

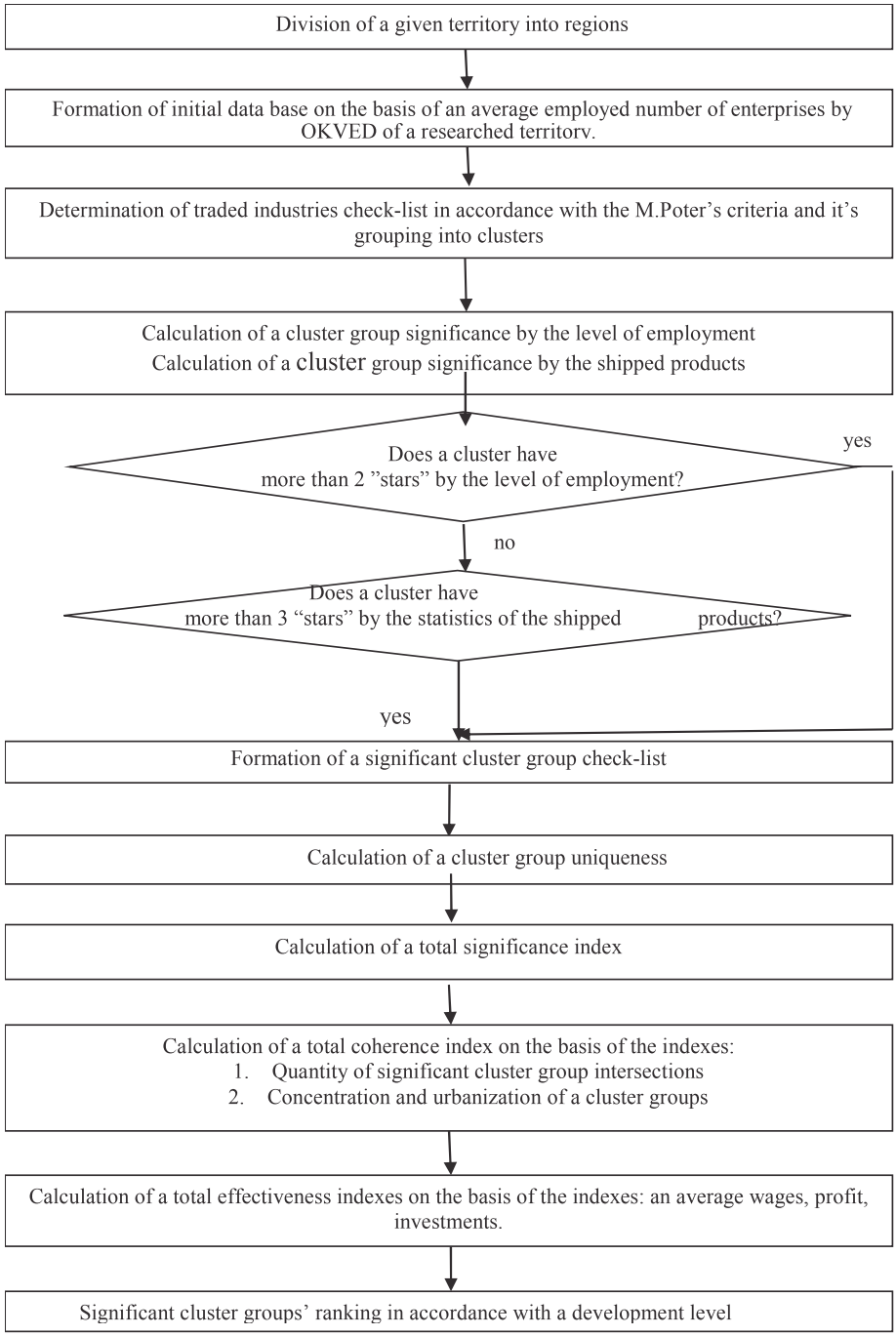

Fig 1. The algorithm of the determination of developed clusters of a region

Methodology

Having analyzed the results of M. Porter research, the European Cluster Observatory and Russian scientists, we propose to use an algorithm to identify and analyze cluster of the economy of the region, which is shown in Fig. 1.

As it is shown in Fig. 1 in the first step a division of the studied area into regions must be performed. Then, in accordance with the M. Porter procedure, it is necessary to divide the entire set of industries NACE classifier into 3 types: local, traded (basic) and resource-dependent, with the help of the criteria used in the methodology of M. Portera, as for further research only tradable sectors are needed. Mainly they constitute the cluster groups. To determine the composition of the cluster groups, i.e. for the formation of branches in cluster groups, we used the result of M. Porter's research. Cluster groups are co-localization patterns of industries or economic agglomeration that unite kind of activities that are interrelated and tend to co-localization.

In the following stages analysis is carried out in accordance with the procedure of the European Cluster Observatory, which is supplemented by the procedure proposed by Russian scientists to determine the level of development of cluster groups.

The methodology of M. Porter was finalized and implemented in the project of the European Cluster Observatory (2014) for the detecting and mapping economic agglomerations in the scale of the European Union. Economic agglomeration - clusters were analyzed using indicators "localization coefficient" (1), "size" (2), "focus" (3).

$$LQ = \frac{Emp_{ig}}{Emp_g} / \frac{Emp_i}{Emp} \quad (1)$$

where LQ – localization coefficient*; Emp_{ig}* – the quantity of employed in cluster group *i* in the region *g*; Emp_g – the general quantity of employed in the region *g*; Emp_i – the quantity of employed in cluster group *i*; *Emp* – the general quantity of employed.

$$Size = \frac{Emp_{ig}}{Emp_i} \quad (2)$$

where Size – the size of the cluster group *i; Emp_{ig}* – the quantity of employed in cluster group i in the region g; Emp_i – the quantity of employed in cluster group i.

$$Focus = \frac{Emp_{ig}}{Emp_g} \quad (3)$$

where Focus – the focus of the cluster group *i; Emp_{ig}* – the quantity of employed in cluster group i in the region g; Emp_g – the quantity of employed in the region g.

G. Lindquist (2009) as a threshold value, characterizing significant cluster groups in the region, sets the following criteria:

1) the coefficient of localization (1) ≥ 2;

2) a region should be among 10% of the leading regions by size (2);

3) a region should be among 10% of the leading regions by focus (3).

Compliance to each criterion means that a cluster group is assigned by "star" (maximum is 3 "star"s). The number of "stars" determines the strength of a cluster group. As a result, the implementation of the described technique allows obtaining data of the number and strength of significant cluster groups in all regions of studied country or group of countries.

However, the procedure of detecting of the cluster groups by the methodology of the European Cluster Observatory is insufficient. It makes it impossible to assess whether these groups have priority with respect to each other, how effective enterprises are, how these groups relate to each other, etc. Another reason for the failure of the calculation is too limited range of indicators (three) under stringent quantitative restrictions and only on the basis of statistics of employment, so in accordance with the algorithm in Fig. 1 calculation methodology is supplemented by statistics indicators of localization of shipped products.

In accordance with the algorithm, the components of the aggregate development of cluster groups are calculated, which are shown in Table 1, and developed by Kiselev A.N., Kutsenko E.S., A.P. Karnaukh (2014). This figure can assess more accurately the potential development of clusters of this or that industry trend in the region. The cumulative rate of development of the cluster group integrates an extended amount of analyzed indicators and involves existing statistics more. Such structuring of the indicators allows not only evaluating the overall development of cluster groups, but to determine the proportion of such development as well. In conclusion, the algorithm clusters are ranked in terms of development.

Table 1: The total index constituents of the cluster groups' development level

Indexes' groups	Indexes' check-list
The indexes of the a cluster group significance	• Indexes of a cluster group significance on the basis of indexes localization, size, focus, calculated by a number of employees and by shipped products cost; • index of uniqueness of a cluster group – Jinny coefficient
The indexes of a cluster group coherence	• quantity of significant cluster group intersections; • indexes of concentration and urbanization of a cluster group
The indexes of an economic effectiveness of a cluster group	• an average wages of employees by a cluster group • profit by a cluster group • investments by a cluster group

Results

As a result of the implementation of the described procedure the following results of a study of the cluster structure of St. Petersburg in comparison with the North-West Federal District were obtained.

Fig. 2 shows the ranks of Saint Petersburg in all identified cluster groups in the North-West Federal District. Rank 1 means that St. Petersburg is a leader in this cluster group, i.e. this cluster group is most concentrated in this region compared to other regions of the county. The diagram assesses accurately the significance of the cluster group within the established criteria.

By the quantity of employed the greatest effect on the economy of St. Petersburg have the following clusters: "Plastics", "Information Technology", "Scientific research activity", "Biopharmaceuticals", "Trade", "Communication equipment", "Analytical Tools", "Aerospace machinery". Enterprises of the given clusters in St. Petersburg generate the greatest employment, compared to similar businesses in the North-Western Federal District, i.e. clusters have a maximum size of the cluster group, as well as prevail in the city's economy by employment statistics, i.e. clusters have a maximum focus. In terms of "size" the city is a leader in almost all the cluster groups; it means that the multi-variant development of cluster groups takes place (Fig. 2).

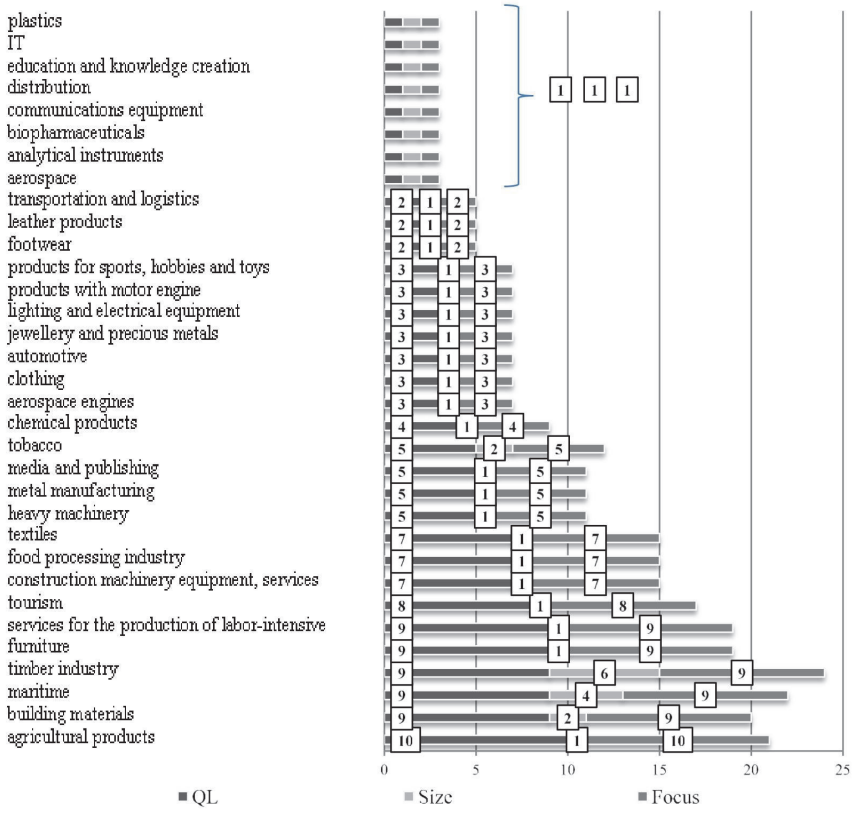

Fig 2. Rank of Saint Petersburg by cluster groups of North-Western Federal District.

Fig. 3 is a diagram, which shows the results of the ranking of cluster groups according to the degree of non-uniformity of their distribution in regions of North-Western Federal District. The most unique in St. Petersburg, rather rare for other entities Northwest FD is a cluster group of "Biopharmaceuticals". Further, the following groups: "Analytical Tools", "Communication equipment", "Leather" and "Aerospace". Other groups demonstrated the lowest uniqueness, i.e. they are present in other regions of the North-West Federal District anywhere.

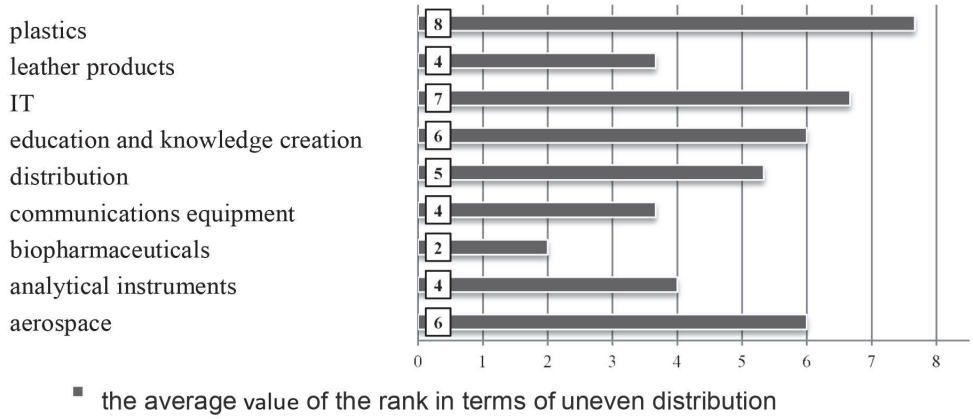

Fig 3. An average value of a cluster group significance rank of Saint Petersburg by the uniqueness index

Thus, the calculation results of the significance of the indicators' group, we can conclude that in St. Petersburg there are nine significant cluster groups. The greatest significance has the "Biopharmaceuticals" cluster, because an employment in this group is very unevenly distributed in regions of North-West Federal District, and this group is concentrated in St. Petersburg. The group leads by the number of the shipped products and by the number of employees in enterprises in this group compared with the industrial structure of the North-West Federal District. Further, in decreasing order of importance the following cluster groups: "Trade", "Information Technology", "Scientific research". Groups: "Analytical instruments", "Communication equipment", "Plastic", "Leather" are equally important for the city. However, the least unique group is "Plastics." Group "Aerospace" is the least important for the city.

Next, we will consider the results of the calculations of the cluster group branches' connectivity indexes. The connectivity data of the cluster groups will help improve the efficiency of cluster policy by means of efforts focusing on support and development of branches of intersecting cluster groups. Fig. 4 shows the intersection of the significant clusters.

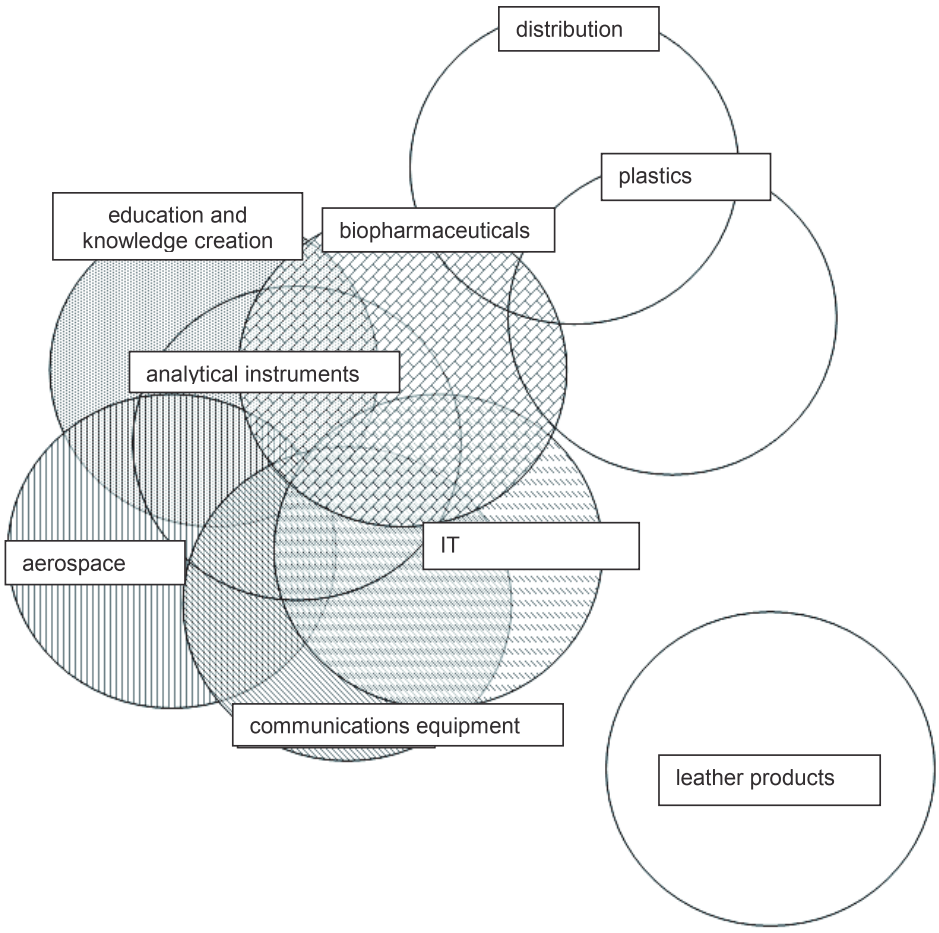

Fig 4. Saint Petersburg significant cluster group intersections

According to the analysis calculations we can draw the following conclusions. A leader in terms of connectivity is a group of "Biopharmaceuticals" – it is associated with the most significant cluster groups in St. Petersburg. Next, it is necessary to point out closely related high-tech cluster groups, "Analytical Tools", "Communication equipment", "Information Technology", "Aerospace". The group "Trade" shows a low rate of coherence with other relevant groups, but the values of the urbanization is the highest, which means that it tends to the other cluster groups that are most represented in St. Petersburg, however, it demonstrates the presence of positive effects of the employees number increasing of the group. The group "Leather" has no relations with other groups, i.e. its support will only affect this given group.

Further, according to the algorithm the cluster groups' effectiveness indicators were analyzed. The results are shown in Fig. 5-8.

Wage levels' leaders are cluster groups: "Information Technologies", "Scientific research" (Fig. 5). Group "Trade", "Leather" are almost two times as behind as others. In other groups, the average wage is about the same.

The cluster group "Leather" by the level of the average level of investment lies behind the other

groups (Fig. 6). The group of "Plastics" is also lagging, where the average investment rate slightly below 1 million rubles. All the other groups have approximately the same values for this index and the average level of investment value in these groups is around 1.5 million rubles.

The absolute leader in terms of profit (Fig. 7) is a group of "Plastics", which exceeds the level of all other groups for almost 20 times. The group of "Leather" products, on the contrary, generates the lowest profit. Gains in other cluster groups are rather evenly distributed between 1.5 and 2 million rubles. However, in the group of "Biopharmaceuticals" profit level slightly higher at 2.6 million.

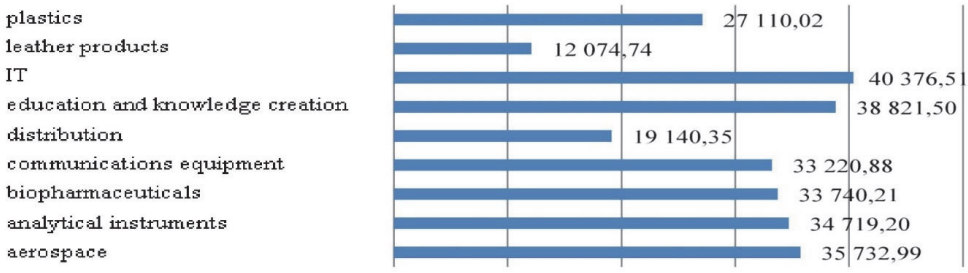

Fig 5. An average wages level in cluster groups, rubles

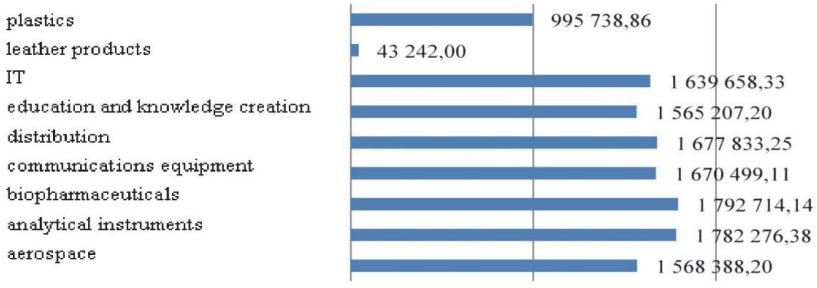

Fig 6. Level of investments in cluster groups, rubles

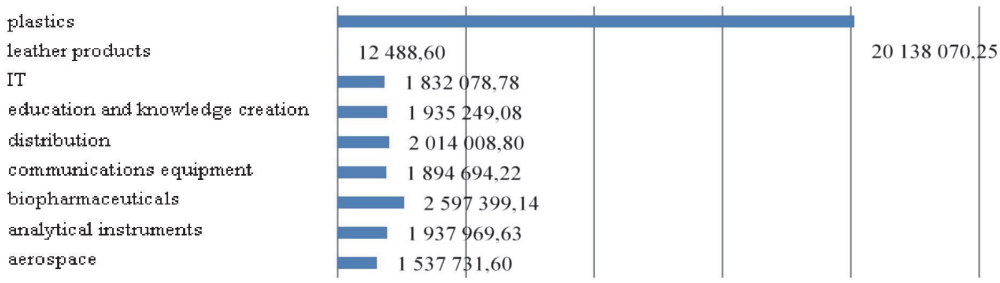

Fig 7. Level of profit in cluster groups, rubles

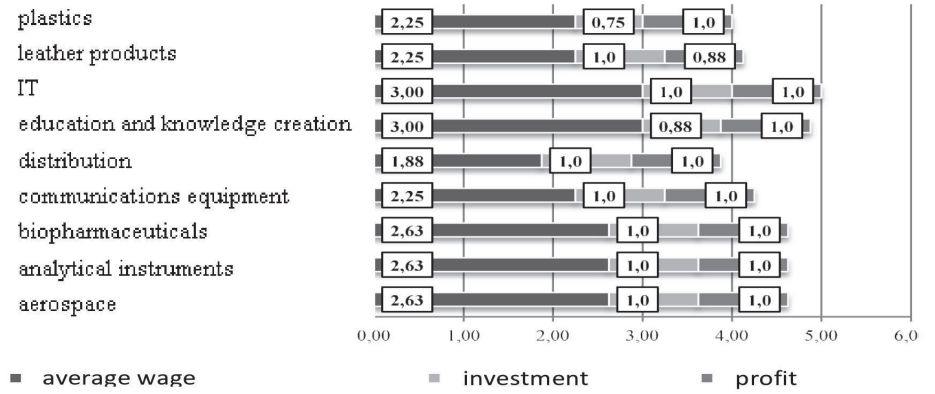

Fig 8. An economic effectiveness index of enterprises in cluster group, points

The results of the synthesis of the cluster groups in terms of economic efficiency scores are shown in Fig. 8.

The leaders in the aggregate indicator of economic efficiency are following cluster groups: "Information Technology", "Scientific research". This means that the enterprise of the given cluster groups in St. Petersburg has the greatest economic effectiveness, compared with similar enterprises in other regions of the North-West Federal District. I.e. Enterprise industries, which are parts of these groups, show the highest level of profit wage and investment activity in comparison with similar businesses entities Northwestern Federal District. After the leading group are the following clusters, "Biopharmaceuticals", "Analytical tools", "Aerospace". The worst results the group "Trade" demonstrates. Enterprises of St. Petersburg are included in this cluster group, lagging far behind in terms of average monthly wages of similar enterprises subjects Northwestern Federal District.

Aggregate indicator of the cluster groups' significance is shown in Figure 9.

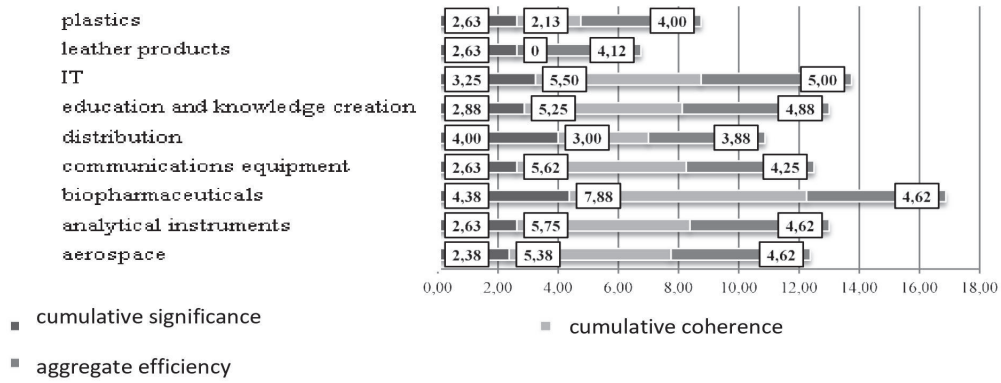

Fig 9. A total index of significant cluster groups' development of Saint Petersburg, points

Thus, the study identified nine significant cluster groups in St. Petersburg, presented in Fig. 9. On the basis of statistical data on the number of employees and the shipped products, it was calculated that these groups prevail in the economy of St. Petersburg in comparison with the industrial structure, both the city and the subjects of the North-West Federal District. The group of "Biopharmaceuticals", "Analytical tools" and "Communication equipment" are the most unique in the city, i.e. these groups are thinly represented or absent in other regions of the North-West Federal District.

It is important to note that all nine groups are at different levels of their development. The leader of the groups is the developed cluster group of "Biopharmaceuticals". This group has the highest significance values, i.e. cluster has the maximum number of points for employment and for the volume of shipped products. That means that the share of employment (shipped products) of the cluster of St. Petersburg in total employment (products shipped) of all cluster groups in the North-West Federal District, as well as in total employment in St. Petersburg is the highest in comparison with the same indexes of the given cluster in the subjects of the North-West Federal District. It means that this cluster prevails in the economy of the city and the North West region by these indicators. The cluster "Biopharmaceuticals" is also the rarest for other subjects of Northwestern Federal District. This group is also leaders in terms of connectivity, i.e. activities, which are included in this group are also in the maximum number of other cluster groups. Enterprises of the cluster are characterized by the highest level of profit, wages and investment activity. Thus, it can be argued that the cluster "Biopharmaceuticals" is the most economically developed in St. Petersburg.

Conclusion

If we analyze the clusters in the order of decreasing of the development level, then we have the following groups: "Information Technology", "Analytical tools", "research activities" and "Communication equipment". These high-tech and science-intensive groups are closely linked and can form a single meta-cluster group. State support of one of these groups, as well as of intersecting branches of this group, will influence both the group itself and other relevant cluster groups.

The group of "Aerospace" has the lowest value of the significance index; it means that this cluster does not prevail in the city's economy in comparison with the cluster structure of the North-West Federal District.

The cluster group "Trade" lags considerably behind the leaders in terms of development. The group is characterized by rather low values of coherence and efficiency indicators, which means that this

group has fewer industries covered by other relevant clusters and enterprise cluster characterized by lower level of economic efficiency.

Low rate of cluster groups' development of "Leather", "Plastics" is explained primarily by low level of coherence or lack of it – "Leather Goods". A support of these groups will not have a multiplicative effect on other significant cluster groups of the city. Also, these groups are characterized by a relatively low level of wages, profits and investment activity of enterprises, which are parts of them.

A development of effective government support measures identified the cluster groups is an opportunity for St. Petersburg to create the conditions for economic modernization and develop the competitive clusters in the global market.

Acknowledgements

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Appendix 2

Table A2.1. Composition and types of investigated clusters

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Кластер			Виды деятельности по NACE (Европа)	Виды деятельности по ОКВЭД (Россия)	
Автомобилестроение	Automotive	22.19	Manufacture of other rubber products	25.1	Производство прочих резиновых изделий
		23.11 23.12	Manufacture of flat glass; Shaping and processing of flat glass	26.1	Производство стекла и изделий из стекла
		30.40	Manufacture of military fighting vehicles		
		29.10	Manufacture of motor vehicles	34	Производство автомобилей, прицепов и полуприцепов
		29.20	Manufacture of bodies (coachwork) for motor vehicles manufacture of trailers and semi-trailers		
		29.32	Manufacture of other parts and accessories for motor vehicles		
Аналитические инструменты	Analytical instruments	26.51	Manufacture of instruments and appliances for measuring, testing and navigation	33.20	Производство приборов и инструментов для измерений, контроля, испытаний, навигации, управления и прочих целей
Аэрокосмическая техника	Aerospace	30.30	Manufacture of air and spacecraft and related machinery	35.30	Производство летательных аппаратов, включая космические
Бизнес услуги	Business Services	77.33	Renting and leasing of office machinery and equipment (including computers)	71.33	Аренда офисных машин и оборудования, включая вычислительную технику
		78.10 78.20	Activities of employment placement agencies; Temporary employment agency activities	74.50	Трудоустройство и подбор персонала
		80.30	Investigation activities	74.60	Проведение расследований и обеспечение безопасности
		82.19 82.30	Photocopying, document preparation and other specialised office support activities; Organisation of conventions and trade shows	74.83 72.84	Предоставление секретарских, редакторских услуг и услуг по переводу; Предоставление прочих услуг 74,8 Предоставление различных видов услуг
		82.20	Activities of call centres	92.40	Деятельность информационных агентств
Биофармацевтика	Biopharmaceuticals	21.10 21.20	Manufacture of basic pharmaceutical products; Manufacture of pharmaceutical preparations	24.4	Производство фармацевтической продукции
		20.42	Manufacture of perfumes and toilet preparations	24.5	Производство мыла; моющих, чистящих и полирующих средств; парфюмерных и косметических средств
Бумажная продукция	Paper products	17.11	Manufacture of pulp; Manufacture of paper and paperboard	21.1	Производство целлюлозы, древесной массы,

Кластер			Виды деятельности по NACE (Европа)	Виды деятельности по ОКВЭД (Россия)	
		17.21 17.22 17.24 17.29	Manufacture of corrugated paper and paperboard and of containers of paper and paperboard; Manufacture of household and sanitary goods and of toilet requisites; Manufacture of wallpaper; Manufacture of other articles of paper and paperboard	21.21 21.22 21.24 21.25	Производство гофрированного картона, бумажной и картонной тары; Производство бумажных изделий хозяйственно-бытового и санитарно-гигиенического назначения; Производство обоев; Производство прочих изделий из бумаги и картона
		22.22	Manufacture of plastic packing goods	25.22	Производ. пластмассовых изделий для упаковывания товаров
Информационные технологии	IT	26.20	Manufacture of computers and peripheral equipment	30.0	Производство офисного оборудования и вычислительной техники
		58.21 58.29 62.01	Publishing of computer games; Other software publishing; Computer programming activities	72.20	Разработка программного обеспечения и консультирование в этой области
Каменоломни	Stone Quarries	08.11	Quarrying of ornamental and building stone, limestone, gypsum, chalk and slate	14.1	Разработка каменных карьеров
Кожаные изделия	Leather products	14.11	Manufacture of leather clothes	19.3	Дубление и отделка кожи, производство чемоданов, сумок, шорно-седельных изделий из кожи; выделка и крашение меха
		14.20	Manufacture of articles of fur	18.30	Выделка и крашение меха; производство меховых изделий
		15.12	Manufacture of luggage, handbags and the like, saddlery and harness	19.20	Производство чемоданов, сумок и аналогичных изделий из кожи и других материалов; производство шорно-седельных и других изделий из кожи
Мебель	Furniture	16.21	Manufacture of veneer sheets and wood-based panels	20.20	Производство шпона, фанеры, плит, панелей
		16.22	Manufacture of assembled parquet floors	20.30	Производство деревянных строительных конструкций, включая сборные деревянные строения, и столярных изделий
		23.49	Manufacture of other ceramic products	26.2	Производство прочих керамических изделий
		31.09	Manufacture of other furniture	36.1	Производство прочей мебели
Медицинские инструменты	Medical devices	26.60 32.50	Manufacture of irradiation, electromedical and electrotherapeutic equipment; Manufacture of medical and dental instruments and supplies	33.10	Производство изделий медицинской техники, включая хирургическое оборудование, и ортопедических приспособлений

Кластер			Виды деятельности по NACE (Европа)	Виды деятельности по ОКВЭД (Россия)	
Металлургическая промышленность	Metal Manufacturing	24.10 24.31 24.32 24.33 24.34 24.51 24.52	Manufacture of basic iron and steel and of ferro-alloys; Cold drawing of bars; Cold rolling of narrow strip; Cold forming or folding; Cold drawing of wire	27.11 27.12 27.13 27.14 27.15 27.16 27.17	Производство чугуна и доменных ферросплавов; *Производство продуктов прямого восстановления железной руды;* Производство ферросплавов, кроме доменных; Производство стали; Производство полуфабрикатов (заготовок) для переката; Производство стального проката горячекатаного и кованого; Производство холоднокатаного плоского проката без защитных покрытий и с защитными покрытиями
		24.51 24.52 24.53 24.54	Casting of iron; Casting of steel; Casting of light metals; Casting of other non-ferrous metals	27.51 27.52 27.53 27.54	Производство чугунных отливок; Производство стальных отливок; Производство отливок из легких металлов; Производство отливок из прочих цветных металлов;
		25.40	Manufacture of weapons and ammunition	29.60	Производство оружия и боеприпасов
		25.50	orging, pressing, stamping and roll-forming of metal powder metallurgy	28.40	Ковка, прессование, штамповка и профилирование; изготовление изделий методом порошковой металлургии
		25.61 25.62	Treatment and coating of metals; Machining	28.51 28.52	Обработка металлов и нанесение покрытий на металлы; Обработка металлических изделий с использованием основных технологических процессов машиностроения
		25.93 25.94 25.99	Manufacture of wire products, chain and springs; Manufacture of fasteners and screw machine products; Manufacture of other fabricated metal products n.e.c.	28.71 28.72 28.73 28.74 28.75	Производство металлических бочек и аналогичных емкостей; Производство упаковки из легких металлов; Производство изделий из проволоки; Производство крепежных изделий, цепей и пружин; Производство прочих готовых металлических изделий
		28.13	Manufacture of other pumps and compressors	29.12	Производство насосов, компрессоров и гидравлических систем
		27.51	Manufacture of electric domestic appliances	29.71 29.72	Производство бытовых электрических приборов; Производство бытовых неэлектрических приборов
		26.52	Manufacture of watches and clocks	33.50	Производство часов и других приборов времени
Наука и образование	Education and Knowledge Creation	72.19	Other research and experimental development on natural sciences and engineering	73.10	Научные исследования и разработки в области естественных и технических наук

Кластер			Виды деятельности по NACE (Европа)	Виды деятельности по ОКВЭД (Россия)	
		72.20	Research and experimental development on social sciences and humanities	73.20	Научные исследования и разработки в области общественных и гуманитарных наук
		73.20	Market research and public opinion polling	74.13	Исследование конъюнктуры рынка и выявление общественного мнения
		85.42	Tertiary education	80.30	Высшее профессиональное образование
		85.41	Post-secondary non-tertiary education	80.41 80.42	*Обучение водителей транспортных средств*; Образование для взрослых и прочие виды образования, не включенные в другие группировки
		91.01 91.02 91.03 91.04	Library and archives activities; Museums activities; Operation of historical sites and buildings and similar visitor attractions; Botanical and zoological gardens and nature reserves activities	92.51 92.52 92.53	Деятельность библиотек, архивов, учреждений клубного типа; Деятельность музеев и охрана исторических мест и зданий; Деятельность ботанических садов, зоопарков и заповедников
Нефть и газ	Oil and Gas	09.10	Support activities for petroleum and natural gas extraction	11.20	Предоставление услуг по добыче нефти и газа
		19.20	Manufacture of refined petroleum products	23.20	Производство нефтепродуктов
		49.50	Transport via pipeline	60.30	Транспортирование по трубопроводам
Обувь	Footwear	15.20	Manufacture of footwear	19.3	Производство обуви
Одежда	Apparel	13.30	Finishing of textiles	17.30	Отделка тканей и текстильных изделий
		13.91	Manufacture of knitted and crocheted fabrics	17.60	Производство трикотажного полотна
		14.31 14.39	Manufacture of knitted and crocheted hosiery; Manufacture of other knitted and crocheted apparel	17.71 17.72	Производство чулочно-носочных изделий; Производство трикотажных джемперов, жакетов, жилетов, кардиганов и аналогичных изделий
		14.12 14.13 14.19	Manufacture of workwear; Manufacture of other outerwear; Manufacture of other wearing apparel and accessories	18.21 18.22 18.23 18.24	Производство спецодежды; Производство верхней одежды; *Производство нательного белья*; Производство прочей одежды и аксессуаров
Освещение и электрооборудование	Lighting and Electrical Equipment	27.12	Manufacture of electricity distribution and control apparatus	31.20	Производство электрической распределительной и регулирующей аппаратуры
		27.40	Manufacture of electric lighting equipment	31.50	Производство электрических ламп и осветительного оборудования
Пластмассы	Plastics	20.16 20.17	Manufacture of plastics in primary forms; Manufacture of synthetic rubber in primary forms	24.16 24.17	Производство пластмасс и синтетических смол в первичных формах; Производство синтетического каучука
		20.30	Manufacture of paints, varnishes and similar coatings, printing ink and mastics	24.30	Производство красок и лаков
		22.29	Manufacture of other plastic products	25.24	Производство прочих пластмассовых изделий

Кластер			Виды деятельности по NACE (Европа)	Виды деятельности по ОКВЭД (Россия)	
Производство и передача энергии	Power Generation and Transmission	27.11	Manufacture of electric motors, generators and transformers	31.10	Производство электродвигателей, генераторов и трансформаторов
		23.43	Manufacture of ceramic insulators and insulating fittings	31.40	Производство химических источников тока (аккумуляторов, первичных элементов и батарей из них)
Развлечения	Entertainment	59.11 59.12 59.13	Motion picture, video and television programme production activities; Motion picture, video and television programme post-production activities; Motion picture, video and television programme distribution activities	92.11 92.12 92.13	Производство фильмов; Прокат фильмов; Показ фильмов
		59.20 90.02 90.04	Sound recording and music publishing activities; Support activities to performing arts; Operation of arts facilities	92.31 92.32 92.33 92.34	Деятельность в области искусства; Деятельность концертных и театральных залов; Деятельность ярмарок и парков с аттракционами; Прочая зрелищно-развлекательная деятельность
		93.11 93.12	Operation of sports facilities; Activities of sport clubs	92.61 92.62	Деятельность спортивных объектов; Прочая деятельность в области спорта
		93.29	Other amusement and recreation activities	92.7	Прочая деятельность по организации отдыха и развлечений, не включенная в другие группировки
Растениеводство и животноводство	Farming and Animal Husbandry	01.11 01.13 01.24 01.25	Growing of cereals (except rice), leguminous crops and oil seeds; Growing of vegetables and melons, roots and tubers; Growing of pome fruits and stone fruits; Growing of other tree and bush fruits and nuts	01.11 01.12 01.13	Выращивание зерновых, технических и прочих сельскохозяйственных культур, не включенных в другие группировки; Овощеводство; декоративное садоводство и производство продукции питомников; Выращивание фруктов, орехов, культур для производства напитков и пряностей
		01.41 01.42 01.45 01.46 01.47 01.49	Raising of dairy cattle; Raising of other cattle and buffaloes; Raising of other cattle and buffaloes; Raising of swine/pigs; Raising of poultry; Raising of other animals	01.21 01.22 01.23 01.24 01.25	Разведение крупного рогатого скота; Разведение овец, коз, лошадей, ослов, мулов и лошаков; Разведение свиней; Разведение сельскохозяйственной птицы; Разведение прочих животных
		77.31	Renting and leasing of agricultural machinery and equipment	71.31	Аренда сельскохозяйственных машин и оборудования
Рыболовство и рыбная продукция	Maritime	01.70	Hunting, trapping and related service activities	01.50	Охота и разведение диких животных, включая предоставление услуг в этих областях

Кластер			Виды деятельности по NACE (Европа)	Виды деятельности по ОКВЭД (Россия)	
		03.11 03.12 03.21 03.22	Marine fishing; Freshwater fishing; Marine aquaculture; Freshwater aquaculture	05.01 05.02	Рыболовство; Рыбоводство
		10.20	Processing and preserving of fish, crustaceans and molluscs	15.20	Переработка и консервирование рыбо- и морепродуктов
		13.94	Manufacture of cordage, rope, twine and netting	17.52	Производство канатов, веревок, шпагата и сетей
С/х продукция	Agricultural Products	01.61 01.62 01.63 01.64	Support activities for crop production; Support activities for animal production; Post-harvest crop activities; Seed processing for propagation	01.41 01.42	Предоставление услуг в области растениеводства; Предоставление услуг в области животноводства, кроме ветеринарных услуг
		10.41	Manufacture of oils and fats	15.41 15.42	Производство неочищенных масел и жиров; Производство рафинированных масел и жиров
		10.81	Manufacture of sugar	15.83	Производство сахара
		11.01	Distilling, rectifying and blending of spirits	15.91 15.92	Производство дистиллированных алкогольных напитков; Производство этилового спирта из сброженных материалов
		11.02 11.03 11.04	Manufacture of wine from grape; Manufacture of cider and other fruit wines; Manufacture of other non-distilled fermented beverages	15.93 15.94 15.95	Производство виноградного вина; Производство сидра и прочих плодово-ягодных вин; Производство прочих недистиллированных напитков из сброженных материалов
СМИ и полиграфия	Media and Publishing	17.23	Manufacture of paper stationery	21.23	Производство писчебумажных изделий
		58.11 58.12 58.14 58.19	Book publishing; Publishing of directories and mailing lists; Publishing of journals and periodicals; Other publishing activities	22.11 22.12 22.13 22.14 22.15	Издание книг; Издание газет; Издание журналов и периодических публикаций; *Издание звукозаписей*; Прочие виды издательской деятельности
		18.11 18.12 18.13 18.14	Printing of newspapers; Other printing; Pre-press and pre-media services; Binding and related services	22.21 22.22 22.23 22.24 22.25	Печатание газет; Брошюровочно-переплетная и отделочная деятельность; Изготовление печатных форм; Прочая полиграфическая деятельность
		18.20	Reproduction of recorded media	22.31 22.32 22.33	Копирование звукозаписей; Копирование видеозаписей; Копирование машинных носителей информации

Продолжение табл. 1.1.

Кластер			Виды деятельности по NACE (Европа)	Виды деятельности по ОКВЭД (Россия)	
Строительные технологии	Building Fixtures	16.29	Manufacture of other products of wood manufacture of articles of cork, straw and plaiting materials	20.51 20.52	Производство прочих Производство изделий материалов для плетения
		22.21 22.23	Manufacture of plastic plates, sheets, tubes and profiles; Manufacture of builders' ware of plastic	25.21 25.23	Производство пластмассовых плит, полос, труб и профилей; Производство пластмассовых изделий, используемых в строительстве
		23.41	Manufacture of ceramic household and ornamental articles	26.21	Производство хозяйственных и декоративных керамических изделий
		23.52	Manufacture of lime and plaster	26.51. 26.52 26.53	*Производство цемента*; Производство извести; Производство гипса
		23.61 23.64 23.65 23.69	Manufacture of concrete products for construction purposes; Manufacture of mortars; Manufacture of fibre cement; Manufacture of other articles of concrete, plaster and cement	26.61 26.62 26.63 26.64 26.65 26.66	Производство изделий из бетона для использования в строительстве; *Производство гипсовых изделий для использования в строительстве; Производство товарного бетона*; Производство сухих бетонных смесей; Производство изделий из асбестоцемента и волокнистого цемента; Производство прочих изделий из бетона, гипса и цемента
		25.12	Manufacture of doors and windows of metal	28.11 28.12	*Производство строительных металлических конструкций;* Производство строительных металлических изделий
		25.21	Manufacture of central heating radiators and boilers	28.21 28.22	*Производство металлических цистерн, резервуаров и прочих емкостей*; Производство радиаторов и котлов центрального отопления
		28.11	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	29.11	Производство двигателей и турбин, кроме авиационных, автомобильных и мотоциклетных двигателей
		28.21	Manufacture of ovens, furnaces and furnace burners	29.21	Производство печей и печных горелок
		31.02 31.03	Manufacture of kitchen furniture; Manufacture of mattresses	36.13 36.15	Производство кухонной мебели; Производство матрасов
Строительство	Construction	08.12	Operation of gravel and sand pits mining of clays and kaolin	14.21 14.22	Разработка гравийных и песчаных карьеров; Добыча глины и каолина
		20.51	Manufacture of explosives	24.61	Производство взрывчатых веществ
		23.32	Manufacture of bricks, tiles and construction products, in baked clay	26.40	Производство кирпича, черепицы и прочих строительных изделий из обожженной глины
		23.51	Manufacture of cement	26.5	Производство цемента

Кластер			Виды деятельности по NACE (Европа)	Виды деятельности по ОКВЭД (Россия)	
		25.11	Manufacture of metal structures and parts of structures	28.1	Производство строительных металлических конструкций
		43.11 43.12	Demolition; Site preparation	45.11	Разборка и снос зданий; производство земляных работ
		41.20 42.11 42.12 42.13	Construction of residential and non-residential buildings; Construction of roads and motorways; Construction of railways and underground railways; Construction of bridges and tunnels	45.21 45.22 45.23 45.24	Производство общестроительных работ; Устройство покрытий зданий и сооружений; Строительство дорог, аэродромов и спортивных сооружений; Строительство водных сооружений
		43.31	Plastering	45.4	Производство штукатурных работ
		77.32	Renting and leasing of construction and civil engineering machinery and equipment	71.32	Аренда строительных машин и оборудования
Табак	Tobacco	12.00	Manufacture of tobacco products	16.00	Производство табачных изделий
Текстиль	Textiles	13.10	Preparation and spinning of textile fibres	17.11 17.12 17.13 17.14 17.15 17.16 17.17	Прядение хлопчатобумажных волокон; Кардное прядение шерстяных волокон; Гребенное прядение шерстяных волокон; Прядение льняных волокон; Изготовление натуральных шелковых, искусственных и синтетических волокон; Производство швейных ниток; Подготовка и прядение прочих текстильных волокон
		13.20	Weaving of textiles	17.21 17.22 17.23 17.24 17.25	Производство хлопчатобумажных тканей; Производство шерстяных тканей из волокон кардного прядения; Производство шерстяных тканей из волокон гребенного прядения; Производство шелковых тканей; Производство прочих текстильных тканей
		13.92	Manufacture of made-up textile articles, except apparel	17.40	Производство готовых текстильных изделий, кроме одежды
		13.93 13.95 13.96 13.99	Manufacture of carpets and rugs; Manufacture of non-wovens and articles made from non-wovens, except apparel; Manufacture of other technical and industrial textiles; Manufacture of other textiles n.e.c.	17.51 17.53 17.54	Производство ковров и ковровых изделий; Производство нетканых текстильных материалов и изделий из них; Производство прочих текстильных изделий, не включенных в другие группировки
		14.14	Manufacture of underwear	18.2	Производство нательного белья
		28.94	Manufacture of machinery for textile, apparel and leather production	29.54	Производство машин и оборудования для изготовления текстильных, швейных, меховых и кожаных изделий

Продолжение табл. 1.1.

Кластер			Виды деятельности по NACE (Европа)	Виды деятельности по ОКВЭД	
Телекоммуникации	Telecom	27.31 27.32	Manufacture of fibre optic cables; Manufacture of other electronic and electric wires and cables	31.30	Производство изолированных проводов и кабелей
		27.90	Manufacture of other electrical equipment	31.62	Производство прочего электрооборудования, не включенного в другие группировки, кроме электрооборудования для двигателей и транспортных средств
		26.30	Manufacture of communication equipment	32.20	Производство передающей аппаратуры, аппаратуры для проводной телефонной и телеграфной связи
		61.10 61.20 61.30 61.90	Wired telecommunications activities; Wireless telecommunications activities; Satellite telecommunications activities; Other telecommunications activities	64.20	Деятельность в области электросвязи
Производственное оборудование	Production Technology	25.30	Manufacture of steam generators, except central heating hot water boilers	28.30	Производство паровых котлов, кроме котлов центрального отопления; производство ядерных реакторов
		28.15	Manufacture of bearings, gears, gearing and driving elements	29.14	Производство подшипников, зубчатых передач, элементов механических передач и приводов
		28.22	Manufacture of lifting and handling equipment	29.22	Производство подъемно-транспортного оборудования
		28.29	Manufacture of other general-purpose machinery n.e.c.	29.24	Производство прочих машин и оборудования общего назначения, не включенных в другие группировки
		28.41	Manufacture of metal forming machinery; Manufacture of other machine tools	29.40	Производство станков
		18.91	Manufacture of machinery for metallurgy	29.51	Производство машин и оборудования для металлургии
		28.96 28.99	Manufacture of plastics and rubber machinery; Manufacture of other special-purpose machinery n.e.c.	29.56	Производство прочих машин и оборудования специального назначения, не включенных в другие группировки
		30.99	Manufacture of other transport equipment n.e.c.	35.50	Производство прочих транспортных средств и оборудования, не включенных в другие группировки
Торговля	Distribution	46.16	Agents involved in the sale of textiles, clothing, fur, footwear and leather goods	51.16	Деятельность агентов по оптовой торговле текстильными изделиями, одеждой, обувью, изделиями из кожи и меха

Кластер			Виды деятельности по NACE (Европа)	Виды деятельности по ОКВЭД (Россия)	
		46.31 46.32 46.34 46.35 46.37 46.38	Wholesale of fruit and vegetables; Wholesale of meat and meat products; Wholesale of beverages; Wholesale of tobacco products; Wholesale of coffee, tea, cocoa and spices; Wholesale of other food, including fish, crustaceans and molluscs	51.31 51.32 51.33 51.34 51.35 51.36 51.37 51.38	Оптовая торговля фруктами, овощами и картофелем; Оптовая торговля мясом, мясом птицы, продуктами и консервами из мяса и мяса птицы; Оптовая торговля молочными продуктами, яйцами, пищевыми маслами и жирами; Оптовая торговля алкогольными и другими напитками; Оптовая торговля табачными изделиями; Оптовая торговля сахаром и сахаристыми кондитерскими изделиями, включая шоколад; Оптовая торговля кофе, чаем, какао и пряностями; Оптовая торговля прочими пищевыми продуктами
		46.41 46.42 46.45 46.46 46.48	Wholesale of textiles; Wholesale of clothing and footwear; Wholesale of perfume and cosmetics; Wholesale of pharmaceutical goods; Wholesale of watches and jewellery	51.41 51.42 51.43 51.44 51.45 51.46 51.47	Оптовая торговля текстильными и галантерейными изделиями; Оптовая торговля одеждой, включая нательное белье, и обувью; *Оптовая торговля бытовыми электротоварами, радио- и телеаппаратурой*; *Оптовая торговля изделиями из керамики и стекла, обоями, чистящими средствами*; Оптовая торговля парфюмерными и косметическими товарами; Оптовая торговля фармацевтическими и медицинскими товарами, изделиями медицинской техники и ортопедическими изделиями; Оптовая торговля прочими непродовольственными потребительскими товарами
		47.91	Retail sale via mail order houses or via Internet	52.61 52.62 52.63	Розничная торговля по заказам; Розничная торговля в палатках и на рынках; Прочая розничная торговля вне магазинов
Транспорт и логистика	Transportation and logistics	30.11 33.15	Building of ships and floating structures; Repair and maintenance of ships and boats	35.1	Строительство и ремонт судов
		49.31	Urban and suburban passenger land transport	60.2	Деятельность прочего сухопутного пассажирского транспорта, подчиняющегося расписанию

Кластер			Виды деятельности по NACE (Европа)	Виды деятельности по ОКВЭД (Россия)	
		50.10 50.20 50.30 50.40	Sea and coastal passenger water transport; Sea and coastal freight water transport; Inland passenger water transport; Inland freight water transport	61.10 61.20	Деятельность морского транспорта; Деятельность внутреннего водного транспорта
		51.10 51.21	Passenger air transport; Freight air transport	62.10	Деятельность воздушного транспорта, подчиняющегося расписанию
				62.20	Деятельность воздушного транспорта, не подчиняющегося расписанию
		52.10	Warehousing and storage	63.11 63.12	Транспортная обработка грузов; Хранение и складирование
		52.21 52.22 52.23	Service activities incidental to land transportation; Service activities incidental to water transportation; Service activities incidental to air transportation	63.21 63.22 63.23	Прочая вспомогательная деятельность сухопутного транспорта; Прочая вспомогательная деятельность водного транспорта; Прочая вспомогательная деятельность воздушного транспорта
		53.10 53.20	Postal activities under universal service obligation; Other postal and courier activities	64.11 64.12	Деятельность национальной почты; Курьерская деятельность
		77.34	Renting and leasing of water transport equipment	71.21 71.22 71.23	*Аренда прочих сухопутных транспортных средств и оборудования*; Аренда водных транспортных средств и оборудования; *Аренда воздушных транспортных средств и оборудования*
Туризм	Tourism	55.10	Hotels and similar accommodation	55.11 55.12	Деятельность гостиниц с ресторанами; Деятельность гостиниц без ресторанов;
		55.20 55.30 55.90	Holiday and other short-stay accommodation; Camping grounds, recreational vehicle parks and trailer parks; Other accommodation	55.21 55.22 55.23	Деятельность молодежных туристских лагерей и горных туристских баз; Деятельность кемпингов; Деятельность прочих мест для проживания
		49.32	Taxi operation	60.22	Деятельность такси
		77.11	Renting and leasing of cars and light motor vehicles	71.10	Аренда легковых автомобилей
		92.00	Gambling and betting activities	92.71	Деятельность по организации азартных игр
		93.21	Activities of amusement parks and theme parks	92.33 92.34	Деятельность ярмарок и парков с аттракционами; Прочая зрелищно-развлекательная деятельность
Тяжелое машиностроение	Heavy machinery	28.25	Manufacture of non-domestic cooling and ventilation equipment	29.23	Производство промышленного холодильного и вентиляционного оборудования

Кластер			Виды деятельности по NACE (Европа)	Виды деятельности по ОКВЭД (Россия)	
		28.30	Manufacture of agricultural and forestry machinery	29.31 29.32	Производство колесных тракторов; Производство прочих машин и оборудования для сельского и лесного хозяйства
		28.92	Manufacture of machinery for mining, quarrying and construction	29.52	Производство машин и оборудования для добычи полезных ископаемых и строительства
		29.31	Manufacture of electrical and electronic equipment for motor vehicles	31.61 31.62	Производство электрооборудования для двигателей и транспортных средств; *Производство прочего электрооборудования, не включенного в другие группировки, кроме электрооборудования для двигателей и транспортных средств*
		30.20	Manufacture of railway locomotives and rolling stock	35.20	Производство железнодорожного подвижного состава (локомотивов, трамвайных моторных вагонов и прочего подвижного состава)
Финансовые услуги	Financial Services	64.11 64.19	Central banking; Other monetary intermediation	65.11 65.12	Деятельность Центрального банка Российской Федерации; Прочее денежное посредничество
		64.20 64.30 64.91	Activities of holding companies; Trusts, funds and similar financial entities; Financial leasing; Other credit granting; Other financial service activities, except insurance and pension funding n.e.c.	65.21 65.22 65.23	Финансовый лизинг; Предоставление кредита; Финансовое посредничество, не включенное в другие группировки
		65.11 65.12 65.20	Life insurance; Non-life insurance; Reinsurance	66.01 66.02 66.03	Страхование жизни и накопление; Негосударственное пенсионное обеспечение; Прочие виды страхования
		66.11 66.12 66.19	Administration of financial markets; Security and commodity contracts brokerage; Other activities auxiliary to financial services, except insurance and pension funding	67.11 67.12 67.13	Управление финансовыми рынками; Биржевые операции с фондовыми ценностями; Прочая вспомогательная деятельность в сфере финансового посредничества
		84.30	Compulsory social security activities	75.30	Деятельность в области обязательного социального обеспечения
Химическая промышленность	Chemical products	15.11	Tanning and dressing of leather dressing and dyeing of fur	19.10	*Дубление и отделка кожи*
		20.11 20.12 20.13 20.14	Manufacture of industrial gases; Manufacture of dyes and pigments; Manufacture of other inorganic basic chemicals; Manufacture of other organic basic chemicals; Manufacture of pesticides and other agrochemical products	24.11 24.12 24.13 24.14	Производство промышленных газов; Производство красителей и пигментов; Производство прочих основных неорганических химических веществ; Производство прочих основных органических химических веществ
		20.41	Manufacture of soap and detergents, cleaning and polishing preparations	24.51	Производство глицерина; мыла; моющих, чистящих полирующих средств

Кластер			Виды деятельности по NACE (Европа)	Виды деятельности по ОКВЭД (Россия)	
		20.52 20.53 20.59	Manufacture of glues; Manufacture of essential oils; anufacture of other chemical products	24.62 24.63 24.64 24.65	**Производство клеев и желатина; Производство эфирных масел;** *Производство фотоматериалов*; *Производство готовых незаписанных носителей информации;* **Производство прочих химических продуктов**
		23.14	Manufacture of glass fibres	26.14	**Производство стекловолокна**
		23.20	Manufacture of refractory products	26.26	**Производство огнеупоров**
		23.91	Production of abrasive products	26.8	**Производство абразивных изделий**
		24.46	Processing of nuclear fuel	23.30	**Производство ядерных материалов**
Ювелирные изделия	Jewellery and Precious Metals	25.71	Manufacture of cutlery	28.61 28.62 28.63	**Производство ножевых изделий и столовых приборов;** *Производство инструментов; Производство замков и петель*
		32.11 32.12	Striking of coins; Manufacture of jewellery and related articles	36.21 36.22	**Чеканка монет и медалей; Производство ювелирных изделий и технических изделий из драгоценных металлов и драгоценных камней**
		32.13	Manufacture of imitation jewellery and related articles	36.61	**Производство ювелирных изделий из недрагоценных материалов**

Appendix 3

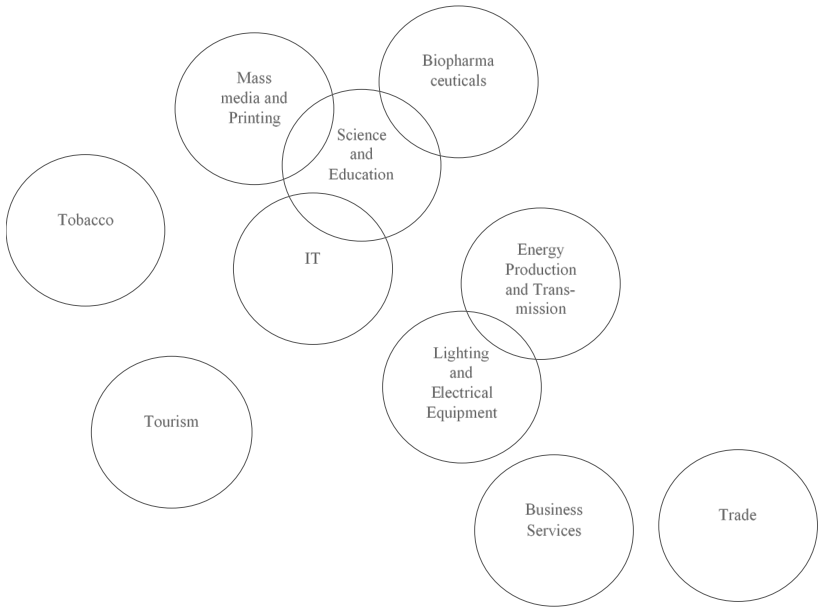

Figure A3.1. Cluster maps of St. Petersburg for 2008 and 2012

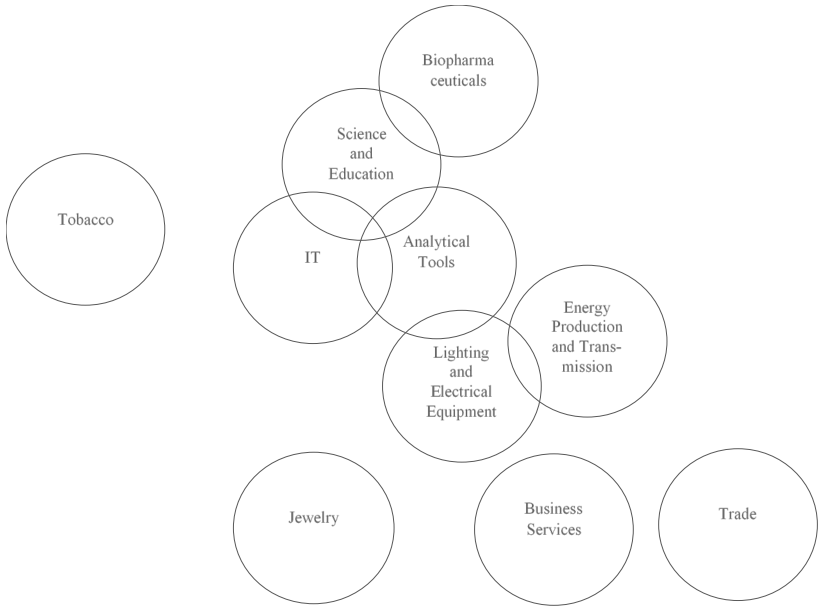

Figure A3.2. – St. Petersburg cluster map in 2012

Appendix 4

Table A4.1. Comparative analysis of clusters localised in St. Petersburg and supported at the federal and regional levels in 2016

State cluster programs		**Cluster cores corresponding to state-supported ones**	
Name	**Support level**	**Clusters that are localised in the region**	**Clusters that are not localised in the region**
Cluster of IT, radio electronics, instrumentation, communications and infotelecommunications	Ministry of Economic Development of the Russian Federation (Innovation Territorial Cluster)	Analytical tools	Telecommunications
		IT	
		Lighting and Electrical Equipment	
		Energy Production and Transmission	
Cluster of medical, pharmaceutical industry, radiation technologies	Ministry of Economic Development of the Russian Federation (Innovation Territorial Cluster)	Biopharmaceuticals	
		Medical Instruments	
Cluster of shipbuilding	Committee for Industry Development and Innovation		Transport and Logistics
Cluster of transport and infrastructure construction	Committee for Industry Development and Innovation		Construction
Cluster of transport engineering	Committee for Industry Development and Innovation		Heavy Engineering
Cluster of mechanical engineering and metalworking			Metallurgical Industry
Composite cluster			
Cluster of aerospace instrumentation	Committee for Industry Development and Innovation		Aerospace Engineering
Polymer cluster	Committee for Industry Development and Innovation	Plastic	
Automotive proto-cluster	Committee for Industry		Automotive Industry

	Development and Innovation		
Cluster of jewellers	Committee for Industry Development and Innovation	Jewellery	
Consumer goods cluster	Committee for Industry Development and Innovation		Clothes
			Footwear
			Textiles

Appendix 5

Table A5.1. Classification of St. Petersburg clusters as of 2016

Cluster classification attribute	Characteristic of the attribute	Clusters of the St. Petersburg region
Explicitly descending form of cluster promotion	The cluster is clearly localised in the region and promoted by the state	Analytical Tools IT Lighting and Electrical Equipment Energy Production and Transmission Biopharmaceuticals Medical Instruments Plastic Jewellery Transport and Logistics
Explicitly ascending form of cluster promotion	The cluster is clearly localised in the region and not promoted by the state	Science and Education Trade Business Services Tobacco Tourism
Implicitly descending form of cluster promotion	The cluster is not clearly localised in the region and promoted by the state	Construction Heavy Engineering Metallurgical Industry Aerospace Engineering Automotive Industry Clothes Footwear Textiles Telecommunications
Implicitly ascending form of cluster promotion	The cluster is not clearly localised in the region and not promoted by the state, based on private initiatives	Not identified

Appendix 6

Table A6.1. Recommended directions for measures of St. Petersburg state cluster policy (a fragment of the table)

	Cluster cores	Measures to be taken to develop the cluster core		Developing related clusters
		Developing staff resources for sectors	Increasing production potentiation of sectors	
Cluster of Information Technology, Radioelectronics, Instrument Engineering, Means of Communication and Infotelecommunications	Analytical Tools			Science and Equipment; Information Technology; Communication Equipment; Lighting and Electrical Equipment; Aerospace Engineering; Medical Instruments
	Information Technology	Developing software and consulting in this field	Manufacturing office equipment and computers;	Science and Education; Analytical Tools; Communication Equipment; Transport and Logistics
	Lighting and Electrical Equipment	Manufacturing electric lightbulbs and lighting equipment	Manufacturing electrical switchgear and relating equipment; Manufacturing electric lightbulbs and lighting equipment	Analytical Tools; Communication Equipment; Energy Production and Transmission; Aerospace Engineering
	Energy Production and Transmission	Manufacturing electric motors, generators and transformers	Manufacturing chemical sources of electric energy (accumulators, primary cells and batteries based on them)	Lighting and Electrical Equipment
	Telecommuni cations		Manufacturing insulated wires and cables	Information Technology; Analytical Tools; Lighting and Electrical Equipment

Curriculum vitae

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Education

2015–2020	Tallinn university of technology – PhD
2016	Peter the Great St. Petersburg Polytechnic University – Continuing education "Modern approaches to educational process management"
2009	Peter the Great St. Petersburg Polytechnic University – Continuing education "Language courses"
2000–2005	Peter the Great St. Petersburg Polytechnic University – Candidate of economics sciences 08.00.05 "Economics and National Economy"
1999–2000	Peter the Great St. Petersburg Polytechnic University – Continuing education "high school teacher"
1995–2000	Peter the Great St. Petersburg Polytechnic University – Specialist "national economy"

Language competence

Russian	native
English	fluent

Professional employment

2016–2020	Peter the Great St. Petersburg Polytechnic University – Vice dean for science and head of the economics direction at Graduate school of industrial economics
2006–2020	Peter the Great St. Petersburg Polytechnic University – Associate professor
2013–2016	Peter the Great St. Petersburg Polytechnic University – Head of the laboratory "Digital economy of the industry"
2005–2006	Peter the Great St. Petersburg Polytechnic University – Senior lecturer

Elulookirjeldus

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2009	Peeter Suure Peterburi Polütehniline Ülikool – Täiendõpe “Keelekursused”
2000–2005	Peeter Suure Peterburi Polütehniline Ülikool – Majandusteaduste kandidaat 08.00.05 “Majandus ja rahvamajandus”
1999–2000	Peeter Suure Peterburi Polütehniline Ülikool – Täiendõpe “Keskkooli õpetaja”
1995–2000	Peeter Suure Peterburi Polütehniline Ülikool – Spetsialist “Rahvamajandus”

Keelteoskus

Vene	emakeel
Inglise keel	kõrgtase

Teenistuskäik

2016–2020	Peeter Suure Peterburi Polütehniline Ülikool – Teadusprodekaan ja tööstusökonoomika doktorikooli majandussuuna juht
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2013–2016	Peeter Suure Peterburi Polütehniline Ülikool – Labori “Tööstuse digitaalmajandus” juhataja
2005–2006	Peeter Suure Peterburi Polütehniline Ülikool – vanemlektor

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