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Innovative Activities in a Region in the Conditions of the Development of the Digital Environment

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Abstract*: *In the conditions of the development of the digital environment, innovative activities become a priority area of economic development that draws not only substantial material and financial resources but also human capital. The existing models designed to assess innovative activities in a region do not give an assessment of conditions for innovative activities. The study aims to develop methods for the assessment of conditions for innovative activities in a region based on a complex consideration of knowledge management factors that allow determining priority areas of regional policy in the digital environment. With regard to the study problems, the authors used a set of basic general scientific methods: comparison, analysis, synthesis, systemization, formalization, statistical estimation, economic mathematical modeling, methods of verifying the reproducibility of the models used on calculation examples. The model presented in the article allows the authors to evaluate the very conditions of innovative activities from the position of knowledge management factors in the conditions of the digital environment. The model's practical application makes it possible to define priority areas for the development of the innovative sector. This, in turn, promotes the formation of the digital environment. The study results have been tested on the example of Russian constituent entities.

Keywords*: *knowledge management, innovation, region, digital environment.

I. INTRODUCTION

The problem of defining priority areas for the regional policy in the conditions of the development of the digital environment is quite urgent because it aims to solve issues related to the formation of a favorable innovative climate.

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Management of a region's innovative activities should be based on a methodology explaining regularities of the interactions among participants of the innovative process considering factors influencing the regional socio-economic system. The triple helix model proposed by H. Etzkowitz [1], which describes regularities of the interactions of authorities, businesses, educational and scientific institutions at the regional level, has been spread as such a methodological basis. At the same time, the scientific problem related to knowledge management in a region is still associated with the determination of indicators characterizing knowledge management factors, which becomes especially important in the conditions of the digital environment, as well as the development of methods designed to evaluate conditions for innovative activities in a region that allow defining priority areas for the regional policy in order to form a favorable innovative climate in the conditions of the digital environment.

This study aims to define priority areas for the regional policy by assessing conditions for innovative activities in a region based on a complex consideration of knowledge management factors in the conditions of the developing digital environment.

The following objectives will be completed by achieving the set goal:

- to substantiate the addition of knowledge management factors to a region's triple helix model;
- to determine indicators characterizing knowledge management factors in the triple helix space;
- to develop a methodology aimed to evaluate conditions for innovative activities in a region by comprehensively considering knowledge management factors.

The article reviews a list of literature on the topic under study, describes the study methodologies and results, based on which conclusions related to the performed work are presented.

II. LITERATURE REVIEW

The concept "knowledge" was first reviewed in scientific publications by the English economist Alfred Marshall [2] who was among the first to include the relevant information in the capital. The next key link in the knowledge management theory was the formation of the concept and main provisions of the knowledge economy, which were proposed by the Austrian and American scholar Fritz Machlup in 1962. Under this concept, he understood one of the economic sectors, in which knowledge plays a decisive role and the production of knowledge is a source of GDP growth [3].

The Austrian economist Joseph Schumpeter thought that the use of new knowledge could boost income and reduce costs by applying innovation [4].

The concept "knowledge management" was first used in 1982 by Karl Wiig, an American scientist and management consultant who indicated the systematic formation, update and application of knowledge in order to maximize the efficiency of business activities [5]. Knowledge management processes at the level of an organization were considered in more detail by the Japanese scientists I. Nonaka and H. Takeuchi [6] who described the lifecycle of knowledge in an organization and the transformation of implicit knowledge into explicit, etc. The fullest classification of knowledge was performed by the Russian economist Boris Milner and it is based on the principles of future actions to be taken by an organization's employees.

The creation of favorable conditions for innovative development of regions is one of the most important objectives of the government policy [7], [8]. Research works by Rudskaya and Rodionov [9]-[15] provide in much detail factors for the management of a region's innovative potential, including knowledge management factors. This leads us to the conclusion that investment in the development of innovation, as well as the promotion of the material and technical base and human potential in regions, contribute to the formation of a favorable environment, promoting the development of innovative activities. Issues related to the development of the digital economy were reflected in detail in the articles written by Bataev [16], [17].

Specific factors for regional knowledge management were studied well in the past. For example, knowledge as a key component of a region's development [18], [19], industrial development in the peripheral regions on the basis of knowledge management [20] and formation of knowledge infrastructure for the purpose of developing a region's innovative activities [21] are components of the triple helix, interactions in the space of institutional areas [1].

Methodological recommendations on the improvement of approaches to regional management in the digital economy were proposed by V. Levizov [22]. These methods are descriptive and do not offer a specific set of indicators that would make it possible to evaluate conditions for innovative activities and to identify priority areas for the development of innovative activities in order to form a favorable innovative climate in the conditions of the digital environment.

The European Innovation Scoreboard, which is applied in the European Union, has become widespread in the international practice [23] and the Portfolio Innovation Index [24] is an assessment system used in the United States. As for the systems designed to evaluate innovative development in the Russian Federation, the Innovative Development Index of Russian regions [25], [26] and the Innovative Development Rating of Russian Regions [27] are the most popular. A number of indicators, which characterize various sides of the object under study are used to evaluate a region's innovative development. Consequently, this gives rise to a question about the comparability of the indicators selected.

The above methods used in assessing innovative activities are based on the determination of the level of a region's innovative development, which suggests taking note not only of the conditions for innovative activities in a region under study but also of resulting indicators of innovative activities. These methodologies are not quite correct because financial costs in an i period are taken into account and the results from innovative activities for the same period are considered while investment in innovative activities will pay back only in the future (various projects will have diverse periods for project completion and payback periods). For this reason, it is necessary to elaborate such methodology of assessing conditions for innovative activities in a region that would make it possible to make a rational decision on priority areas of the regional policy in the conditions of the developing digital environment.

The analysis of literature allowed us to put forward the following hypothesis: the substantiated goal-oriented development of modern infrastructure and human potential in a region promote the formation of a favorable environment, which contributes to the development of innovative activities.

III. PROPOSED METHODOLOGY

A. General description

The analysis of the following methods of assessment of a region's innovative development allowed us to conclude that, in addition to input indicators, which characterize innovative conditions, these methods also include output indicators describing innovative results: European Innovation Scoreboard, Portfolio Innovation Index, Innovative Development Index of Russian Regions, Innovative Development Rating of Russian Regions. As results from the execution of innovative projects will be obtained only in the future (with diverse innovative projects having various execution and payback periods), it is not quite correct to take into consideration input and output data for one and the same period. Thus, it looks reasonable to make an assessment by taking note of input data because they characterize conditions for innovative activities.

The list of selected indicators is shown in Table I.

Table- I: Indicators of a group of factors influencing conditions for innovative activities

#	Group of factors	Indicator	Calculation formula
1	Indicators showing uneven expansion of a region's economic potential	The unevenness ratio between domestic R&D costs and GRP	$k_{ij}^{R\&D\ costs} = x_{ij}^{R\&D\ costs} \Big/ x_i^{*R\&D\ costs}$

		The unevenness ratio between ICT costs and GRP	$k_{ij}^{ICT\ costs} = x_{ij}^{ICT\ costs} / x_i^{*ICT\ costs}$
		The unevenness ratio between R&D employee wages and average employee wages	$k_{ij}^{wage} = x_{ij}^{wage} / x_i^{*Wage}$
2	Indicators showing uneven security of conditions for a region's human potential formation and development	The unevenness ratio between R&D employees and the region's employed total	$k_{ij}^{R\&D\ Ind} = x_{ij}^{R\&D\ Ind} / x_i^{*R\&D\ Ind}$
		The unevenness ratio between researchers with degrees and R&D employees	$k_{ij}^{Degrees} = x_{ij}^{Degrees} / x_i^{*Degrees}$
		The unevenness ratio for the reproduction of highly-qualified staff	$k_{ij}^{HQ} = x_{ij}^{HQ} / x_i^{*HQ}$
3	Indicators showing uneven formation and support of knowledge generation sources	The unevenness ratio for the region's innovative activities	$k_{ij}^{IA} = x_{ij}^{IA} / x_i^{*IA}$
		The unevenness ratio for the security of conditions for the reproduction of highly-qualified researchers	$k_{ij}^{HQRW} = x_{ij}^{HQRW} / x_i^{*HQRW}$
		The unevenness ratio between enterprises with broadband Internet access and the total number of enterprises	$k_{ij}^{IntA} = x_{ij}^{IntA} / x_i^{*IntA}$

When evaluating conditions for innovative activities, it is reasonable to use an approach, which is based on the concept of an ideal system. An ideal system is understood as the best system, which operates in ideal conditions. It is appropriate to use this approach because

- the idea of an ideal system, which is the ultimate and hard to achieve, is not violated;
- regions are assessed from the viewpoint of mutual relations among them, which goes in line with the system approach;
- interests of the state and regions are interrelated and aim to secure socio-economic stability;
- it provides the possibility of performing a quantitative assessment of the conditions for innovative activities.

B. Algorithm

In the course of the study, we developed an algorithm for the assessment of innovative conditions, which suggests the step-by-step implementation of the stages below.

Stage 1. Data collection. We used the Federal Statistics Service's official collections "Russian Regions: Socio-Economic Indicators" [28], [29] as input data. The application of the unified database for the study provides the following advantages:

- a unified methodological and methodical statistical base is secured for all indicators and objects under analysis;
- reliable information is secured;
- it is possible to update and supplement analysis on an annual basis and, consequently, perform continuous monitoring of conditions for the formation and management of the regional innovation policy.

Stage 2. Data preparation. At this stage, collected statistical materials are brought to the comparable and/or integrated form (indicators shown in Table 1 are determined for every region in a specific period of time).

Stage 3. Record numbers are revealed in the aggregate of indicators under analysis. Maximum figures in the aggregate under study are selected as the highest value for all indicators.

Stage 4. Ratios showing uneven development in the conditions for the formation and the conduct of innovative activities in a region are calculated. Deviations between really achieved indicators in every point of time from the highest numbers of the ideal system are determined at this stage.

Stage 5. Conditions for a region's innovative activities are assessed. This stage implies the calculation of three ratios for each group of the region's knowledge management factors. The indicators are calculated as a geometric mean of uneven development ratios, which were calculated in Stage 4.

$$K_{eij} = \left(\prod_{l=1}^{3} k_{ij}^{l}\right)^{1/3} \quad (1)$$

where K_{eij} is the integral criterion of economic conditions for innovative activities in j region during i period of time;

K_{ij}^{l} is the value of the 1st ratio of uneven development in knowledge management indicators in j region during i period of time.

$$K_{chij} = \left(\prod_{l=1}^{3} k_{ij}^{l}\right)^{1/3} \quad (2)$$

where K_{chij} is the integral criterion of conditions for the development of human potential in j region during i period of time.

$$K_{iij} = \left(\prod_{l=1}^{3} k_{ij}^{l}\right)^{1/3} \quad (3)$$

where K_{iij} is the integral criterion of conditions for the development of knowledge sources in j region during i period of time.

This methodology allows us to define those areas of the regional innovation policy that should be developed for the formation of sustainable and balanced development of the region and for the purpose of forming the digital environment in its area, which promotes the intensification of innovative processes.

IV. RESULT ANALYSIS

Integral criteria for knowledge management factors which are calculated for constituent entities from the Northwestern Federal District (NWFD) of the Russian Federation are shown in Table II.

Table- II: Integral indicators of conditions for innovative activities

Regions	Expansion of the region's economic potential		Ensuring conditions for the formation and development of the region's human potential		Formation and support of knowledge generation sources in the region	
	2015	2016	2015	2016	2015	2016
Saint Petersburg	0.644	0.489	0.563	0.558	0.353	0.361
Pskov region	0.205	0.168	0.266	0.159	0.229	0.186
Novgorod region	0.321	0.269	0.153	0.160	0.525	0.568
Murmansk region	0.256	0.208	0.267	0.255	0.272	0.301
Leningrad region	0.378	0.205	0.152	0.155	0.488	0.470
Kaliningrad region	0.207	0.168	0.204	0.223	0.305	0.296
Vologda region	0.119	0.107	0.156	0.159	0.145	0.157
Arkhangelsk region	0.204	0.171	0.164	0.177	0.269	0.283
Republic of Komi	0.230	0.198	0.273	0.284	0.259	0.261
Republic of Karelia	0.234	0.191	0.276	0.289	0.209	0.211

It is possible to monitor the decrease in the development of economic conditions in all NWFD constituent entities on the basis of data shown in Table 2. Above all, this is attributable to substantial GRP growth in 2016 and, at the same time, the moderate increase in domestic R&D and ICT costs in NWFD constituent entities. In some cases, for example in Saint Petersburg, ICT costs decreased by the factor of 1.5 in 2016 compared to 2015. The pace of the region's economic development is substantially faster than the growth rate (and often the decrease) of economic conditions for innovative activities. In addition, one may note an increase in the integral indicator of knowledge sources virtually in all constituent entities, except for the Pskov, Leningrad and Kaliningrad regions.

However, 6 out of 10 regions are characterized by the most unfavorable conditions, namely the Novgorod, Leningrad, Kaliningrad, Vologda, Pskov and Arkhangelsk regions. Based on the estimates of human potential development, Saint Petersburg is also characterized by appropriate conditions for the formation and management of the regional innovation policy. As for the assessment of knowledge sources, in this category, only one region (the Novgorod region) managed to enter the group with acceptable conditions for the formation and management of the regional innovation policy.

Saint Petersburg stands out among other objects under analysis as its estimates (for the development of economic conditions and conditions for human potential development) are part of the acceptable interval. For the development of innovative activities in this constituent entity, it is necessary only to adjust a program designed to improve conditions for the formation and the conduct of innovative activities. Saint Petersburg's estimate of the conditions for the development of knowledge sources is in the 0.25-0.5 group and it is necessary to change considerably regional authorities' approach to the conditions for the formation and the conduct of innovative activities in terms of database development. The Pskov and Vologda regions are the only NWFD constituent entities, conditions for the formation and the conduct of innovative activities in which are the most unfavorable by all three indicators, and the improvement of the current situation, the participation of both regional and federal authorities is required. The formation and development of the digital environment both regionally and nationwide [30], [31] require monitoring of indicators for knowledge management factors, which are seen in the triple helix subspaces characterizing conditions for innovative activities.

V. DISCUSSION

In the article, we upgraded current algorithms aimed to evaluate conditions for innovative activities in a region based on a complex consideration of knowledge management factors in the triple helix subspaces.

Moreover, the study allows us to define priority areas for the regional innovation policy, which are based on the evaluation of conditions for innovative activities within the developing digital environment.

To execute national priorities, it is necessary to set regional priorities for innovative development that do not contradict the country's interests as a whole. To this end, it is essential to elaborate innovative development strategies of regions, to highlight priorities and directions of development, the definition of which is based on the assessment of conditions for a region's innovative activities, and to elaborate the relevant innovation policy.

We can propose the following forms of interaction among institutions, which are involved in the innovation policy:

1. when expanding a region's economic potential:
   - state funding of R&D;
   - elaboration of a system of direct mechanisms that promote the creation of a favorable innovative climate;
   - development of modern infrastructure required for R&D in a region;
   - stimulating payments to employees and organizations, which execute innovative projects.
2. when ensuring conditions for the formation and development of a region's human potential:
   - subsidization of further training courses for employees involved in R&D;
   - measures to popularize sciences among young people in order to attract young researchers;
   - measures to increase the availability of programs designed to train research and educational staff (post-graduate students).

3. when forming and supporting knowledge generation sources:

• measures to offer incentives for corporate innovative activities as a collective source of knowledge generation;

• measures to increase the availability of programs designed to train research and educational staff (doctoral students) as an individual source of knowledge generation;

• measures to develop the modern infrastructure required for the transfer of knowledge.

Channeling investment in the development of innovative activities, it is essential to pay closer attention to bottlenecks of a specific region. Let us take the Leningrad region as an example. Based on 2016 calculations, the region's indicator showing the development of economic conditions stood at 0.21; the gauge indicating conditions for human potential development came in at 0.15; the indicator of knowledge sources reached 0.47.

The general index of conditions for the Leningrad region's innovative development equaled 0.17, marking this constituent entity as the 77th in the innovative development rating. As a consequence, if the smallest indicator is viewed as more important when distributing investment, this will increase the general integral indicator, thus making it possible to achieve balanced development of NWFD constituent entities.

We believe that this result will contribute to solidifying the long-term result as opposed to momentary decisions related to the execution of separate projects.

VI. CONCLUSION

Based on the components of knowledge management factors in the triple helix space, which directly or indirectly include ICT indicators, it is evident that substantiated goal-oriented development of modern infrastructure and human potential in the regions promote the formation of a favorable environment, which contributes to the development of innovative activities and, as a consequence, the proposed hypothesis can be considered proven.

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