Anna A. Mikhaylova, Andrey S. Mikhaylov, Oksana V. Savchina, Angelina P. Plotnikova (2019). Innovation landscape of the Baltic region. *Administratie si Management Public*, (33), pp. 165-180, DOI: 10.24818/amp/2019.33-10.

Innovation landscape of the Baltic region

Anna A. MIKHAYLOVA[1], Andrey S. MIKHAYLOV[2 3], Oksana V. SAVCHINA[4], Angelina P. PLOTNIKOVA[5]

Abstract: *Innovation studies are at the forefront of contemporary applied research with public authorities funding annual evaluation of regional and national innovation performance. Numerous innovation indexes are introduced providing the track of innovation trajectories within multiple dimensions. The current study focuses on the multi-level assessment of territorial innovation system capacity. The research methodology is designed to enable the comparison of national and regional level innovation systems. The evaluation procedure is held across 15 individual indicators structured in five dimensions: human resources, infrastructure, research, innovative milieu, framework conditions. The indicators selected are available for international comparisons in the context of country-region assessment. The research scope is the Baltic region – one of the most innovative macro-region in the world. The study results confirm the strong polarization of the Baltic region in terms of innovation potential and its development dynamics. Lithuania – one of the least performing national innovation systems in 2012, has considerably improved its potential by 2017. The innovation capacity of the North-Western Federal District of the Russian Federation is a third higher than the national average, making it the growth pole of the national innovation system. Top-performing territorial innovation systems are characterized by a strong convergence of all dimensions analyzed. The policy recommendations drawn from the study argue for the coherent development of all aspects of innovation development, ensuring their synergy and cross-fertilization.*

Keywords: *national innovation system, Baltic region, innovation security, innovation policy*

JEL: E660, O380, O520
***DOI*:** 10.24818/amp/2019.33-10

[1] Senior research fellow, PhD, Immanuel Kant Baltic Federal University, A. Nevskogo 14 Str., Kaliningrad, 236014, Russia, e-mail: tikhonova.1989@mail.ru
[2] Associate Professor, PhD, Immanuel Kant Baltic Federal University, A. Nevskogo 14 Str., Kaliningrad, 236014, Russia; e-mail: AndrMikhailov@kantiana.ru
[3] Lead research fellow, PhD, Saint Petersburg Electrotechnical University "LETI", Professora Popova 5 Str., 197376, St. Petersburg, Russia; e-mail: mikhailov.andrey@yahoo.com
[4] Associate Professor, PhD, Peoples' Friendship University of Russia (RUDN University), Miklukho-Maklaya 6 Str., Moscow, 117198, Russia; e-mail: savchina_ovl@ rudn.university
[5] Student, Immanuel Kant Baltic Federal University, A. Nevskogo 14 Str., Kaliningrad, 236014, Russia; e-mail: APPlotnikova@stud.kantiana.ru

Introduction

Despite the frequent propositions on the all-encompassing globalization and the "death" of geography, innovation activity remains to be highly place-sensitive. Unlike an industrial production process being increasingly dispersed along global value-added chains, innovations cluster in local nodes of global innovation networks. They form creative spaces, an innovation-enabling ecosystem that boosts regional development via 'untraded interdependencies' (Storper, 1995) between organizations beyond industry classifications and institutional boundaries (Carayannis & Campbell, 2009). As noted by Carlsson and Stankiewicz (1991, p. 115), "high technological density and diversity are properties of regions rather than countries". Cluster and innovation policies foster the positive externalities generated by these growth nodes, which are further diffused on to adjacent territories (Breschi & Lissoni, 2001; Caragliu & Nijkamp, 2016). Public support for inter-regional networking enables to disseminate best practices and integrate peripheral territories in the value co-creation process, while the cohesion policies aim at leveling out regional divergence by closing the development gaps with place-specific initiatives.

Annual reports on national and regional innovation systems are produced by numerous international institutions using a variety of methodologies. Most are limited by statistical records (e.g. national, pan-European – Eurostat; OECD; World Bank; Ohanyan, Androniceanu, 2017) and none offer a uniform integrated assessment of innovation performance for comparing the national and regional levels of territorial systems.

This study presents the methodology applicable for comparative assessment of territorial innovation systems beyond administrative-territorial boundaries. This will enable to draw a comparison between a set of territorial innovation systems within a particular macro-region that encompasses areas of different administrative subdivisions of countries. In the next section of the article, we give a survey on available approaches to innovation performance evaluation. Section 2 describes the methodology for our study and Section 3 provides the research results. The paper closes with some discussion and conclusions.

1. Literature review

Measuring innovation is an uneasy task. Most competitiveness factors of modern learning (Lundvall, Johnson, 1994), knowledge-based (OECD, 1996), innovation-driven (Gackstatter et al., 2014) economy is increasingly reliant on intellectual capital and entrepreneurial capabilities – the intangible characteristics of the milieu. The efforts of public authorities on strengthening the territorial capital (Cojanu, Robu, 2019; Osipov et al., 2019) are aimed at creating favorable conditions for talents, creativity and innovative entrepreneurs, building public

spaces and advanced facilities for high-technology and knowledge-intensive companies to operate, such as science and technology parks, technopoles, business incubators, centers for collective use. Thus, conventional industry-based methods of performance indicators are not suitable.

A methodology on territorial innovation system capacity should go beyond measuring the volume of new products, production processes, and business practices introduced in the marketplace (Moris et al. 2008; Barmuta et al., 2019); it should capture innovation activities defined as "the scientific, technological, organizational, financial, and commercial steps" leading to innovation (OECD, 2005, p. 40). With that, it is difficult to find a consistent and comparable set of indicators to analyze a heterogeneous set of regions. Data availability is one of the major reasons for using patent- and research and development statistics for constructing an innovation index. Various kinds of scientometric indicators (patents, publications, utility models) are applied for being uniform internationally and being available for all hierarchical levels – cities, regions, and states. However, as argued by Makkonen and van der Have (2013), not all R&D efforts are necessarily commercialized and result in successful innovation outputs, hence, they are limited in characterizing the diversity of elements that constitute innovation systems.

The most advanced methods synthesize information on input and output factors provided by numerous sources and a variety of indicators measuring the preconditions, the capacity for, or the performance of innovative activity into one combined measure – the composite innovation index (Booysen 2002; Carayannis, Provance 2008; Coad, Rao 2008; Tang, Le 2007). Some of the indicators are found to be complementary, while others substitutive (Serrano-Bedia et al., 2018). One of the best practices is an example of the European Innovation Scoreboards (EIS) project for the European Commission. This composite innovation index is held since 2001, making it one of the oldest and most complex assessments of national innovation systems. The innovation index is based on the four main types of indicators – framework conditions, investments, innovation activities, and impacts, which are used to differentiate countries into innovation performance groups: innovation leaders, strong innovators, moderate innovators, and modest innovators. In addition, there is a Regional Innovation Scoreboard (RIS), which is a regional extension of the EIS based on a limited number of indicators. However, a direct comparison of the two scales analyzed in impossible, as a simple sum of sub-national systems of innovation cannot by any means be considered representative of the national innovation system (Iammarino, 2005).

2. Research methodology

The research scope are the innovation systems of the Baltic region countries, including Scandinavia (Denmark, Norway, Sweden, Finland), Germany, Poland, the Baltic states (Lithuania, Latvia, Estonia), and Russia. Generally, only the North-Western Federal District (NWFD) of the Russian Federation is considered as part of the Baltic region, thus, it is included in the study. Whereas the nationwide data for Russia is predominantly used to display the position of the NWFD within the country. An idea on special approach to a comparative evaluation of innovation potential between the national and regional level is adopted from Voloshenko and Mikhailova (2013). The methodology used is based on the following research principles: ensuring comparability of indicators for international comparisons in the context of country-region assessment; prioritizes the official statistical databases; complies with the criteria of comparability, consistency, necessity, sufficiency, and relevance in the selection of indicators; inclusion of those indicators having a percentage expression.

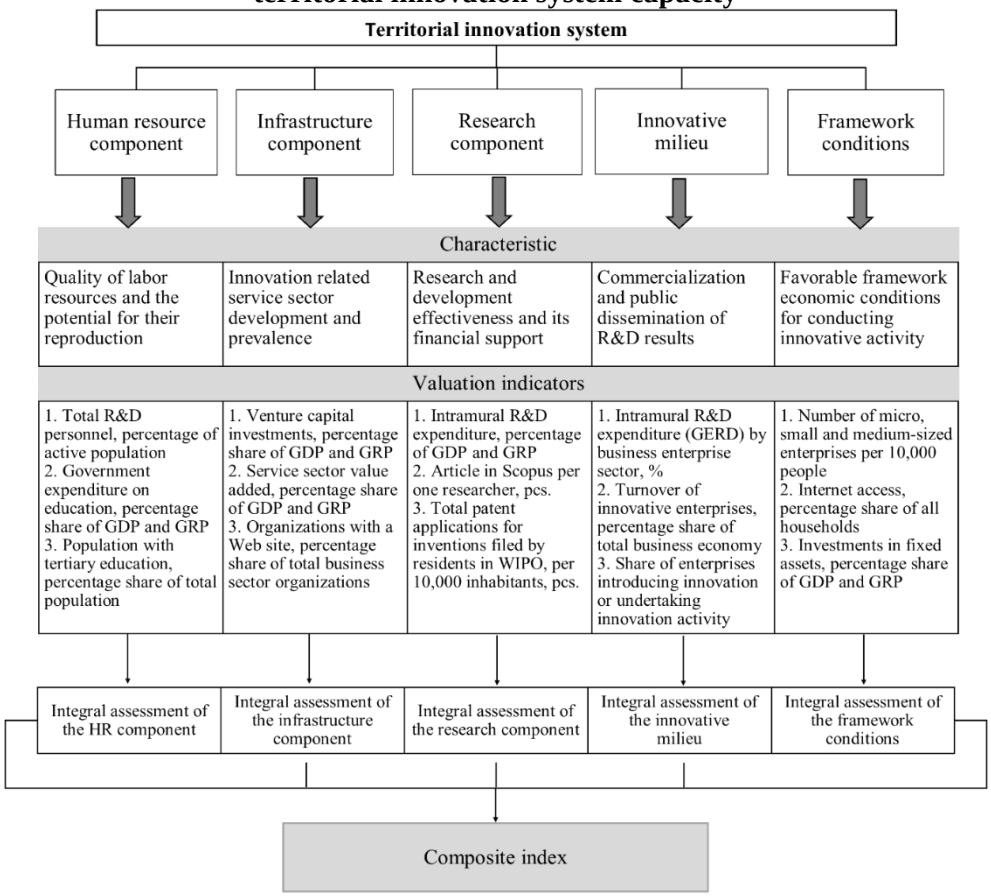
The research methodology is based on the idea of a territorial innovation system as a complex system, which is reflected in the accounting of indicators for all its structural components: human resources, infrastructure, research, innovative milieu, framework conditions (Figure 1).

The research algorithm includes six stages:

I. data collection by indicators on individual components of the territorial innovation system capacity;
II. formation of a database of indicators and their measurement;
III. standardization of indicators by the method of linear scaling in each year under study;
IV. calculation of integral index value by the method of simple arithmetic mean for each component of the territorial innovation system capacity in each year under study;
V. evaluation of the annual integral index value as the average of the arithmetic composite indexes;
VI. classifying the territorial innovation systems by the level of the annual integrated index and calculation of the composite index for each of the selected groups for the whole period.

The study covered the six-year period from 2012 to 2017. Standard extrapolation method is applied for individual indicators with unavailable data for a particular year within the period. Methodological features of data collection and evaluation of indicators for assessing the capacity of innovation systems of the Baltic region states and the North-West Federal District of the Russian Federation are presented in Table 1.

Figure 1. The methodology for calculating the composite index of a territorial innovation system capacity



(Source: the authors own contribution)

Table 1. Detailed information on the methodology of data processing

Indicator	Evaluation procedure and data source
Human resource component	
Total R&D personnel*, percentage of active population (*numerator in head count)	Indicator available on the Eurostat for the EU member states and Norway. Data for Russia and NWFD is calculated as the ratio of personnel engaged in R&D to the number of economically active population (EAP) using Rosstat.
Government expenditure on education, percentage share of GDP (*GRP in case of NWFD of Russia)	Indicator available on the World Bank for the EU member states and Norway (2011-2015); for 2016 it is calculated at Eurostat as Public expenditure on education by education level.

Indicator	Evaluation procedure and data source
	Rosstat and Electronic budget data used for Russia and NWFD; indicator is calculated as the volume of expenditures of the consolidated budget on education to GDP (GRP).
Population with tertiary education, percentage share of total population	Indicator available on the OECD for the EU member states and Norway. Data for Russia and NWFD is calculated as the proportion of the population with postgraduate, higher and incomplete higher education in the structure of the population, indicating their level of education using population census of 2010.
Infrastructure component	
Venture capital investments, percentage share of GDP (*GRP in case of NWFD of Russia)	Denmark, Germany, Finland, Sweden, Norway: OECD database for 2012-2015; Invest Europe and Eurostat databases for 2016-2017. Russia: OECD database for 2012-2017. Estonia, Latvia, Lithuania, Poland: OECD database for 2012; Invest Europe and Eurostat databases for 2013-2017. OECD – indicator available; Invest Europe, Eurostat, Rosstat – the indicator is calculated as the volume of venture investments to GDP (GRP for NWFD).
Service sector value added, percentage share of GDP (*GRP in case of NWFD of Russia)	Indicator available on the World Bank for the EU member states and Norway. Rosstat data for Russia and NWFD is calculated as the total contribution of economic activities to GDP (GRP for NWFD), including Activities in the field of culture, sports, leisure and entertainment; Administrative activities and related services; Education; Financial and insurance activities; Health and social work; Hotels and catering establishments; Information and communications activities; Professional, scientific and technical activities; Public administration and military security; Real estate; Repair of motor vehicles and motorcycles; Social security; Transportation and storage; Wholesale and retail trade; Other types of services.
Organizations with a Web site, percentage share of total business sector organizations	Indicator available on the Eurostat for the EU member states and Norway. Indicator for Russia and NWFD is available at Rosstat.
Research component	
Intramural R&D expenditure (GERD), percentage of GDP (GRP for NWFD)	Indicator available on the Eurostat for the EU member states and Norway. Indicator for Russia and NWFD is available at Rosstat.
Article in Scopus per one researcher, pcs.	The indicator is calculated as the ratio of the number of articles in the Scopus citation database for a given year to the number of researchers in that year. Data on the number of researchers is sourced from Eurostat and Rosstat.

Indicator	Evaluation procedure and data source
Total patent applications for inventions filed by residents in WIPO, per 10,000 inhabitants, pcs.	The indicator is calculated as the ratio of the number of patent applications for inventions in the WIPO database in a given year to the population in that year. WIPO database is used for indicator of Total patent applications (direct and PCT national phase entries). Population figures for the EU member states and Norway is sourced from Eurostat, for Russia and the NWFD – Rosstat.
Innovative milieu	
Intramural R&D expenditure (GERD) by business enterprise sector, percentage share	Indicator available on the Eurostat for the EU member states and Norway. Indicator for Russia and NWFD is calculated as the ratio of the total amount of funds of organizations of the business sector and own funds of scientific organizations to the internal costs of R&D using Rosstat.
Turnover of innovative enterprises, percentage share of total business economy	Indicator available on the Rosstat for Russia and NWFD. For the EU member states and Norway Eurostat database is used; the indicator is calculated as the ratio of turnover of innovative enterprises to turnover or gross premiums written of total business economy; repair of computers, personal and household goods; except financial and insurance activities.
Share of enterprises introducing an innovation or undertaking innovation activity	Indicator available on the Eurostat for the EU member states and Norway. Indicator available on the Rosstat for Russia and NWFD.
Framework conditions	
Number of micro, small and medium-sized enterprises per 10,000 people	OECD database is used for the EU member states and Norway; the indicator is calculated as the ratio of the total number of Enterprises, excluding Enterprises with above 250 persons employed, to the population. Rosstat database is used for Russia and NWFD; the indicator is calculated as the total number of micro, small and medium enterprises to the population.
Internet access, percentage share of all households	Indicator available on the OECD database for the EU member states and Norway. Indicator for Russia and NWFD is available at Rosstat.
Investments in fixed assets, percentage share of GDP (GRP)	Indicator available on the Eurostat for the EU member states and Norway. Indicator for Russia and NWFD is available at Rosstat.

(Source: the authors own contribution)

3. Research results

Table 2 presents the composite index assessment of the potential of territorial innovation systems of the NWFD of the Russian Federation and the countries of the Baltic region in 2012-2017.

Table 2. Composite index of the territorial innovation system capacity for the Baltic region countries and the NWFD of Russia, 2012-2017

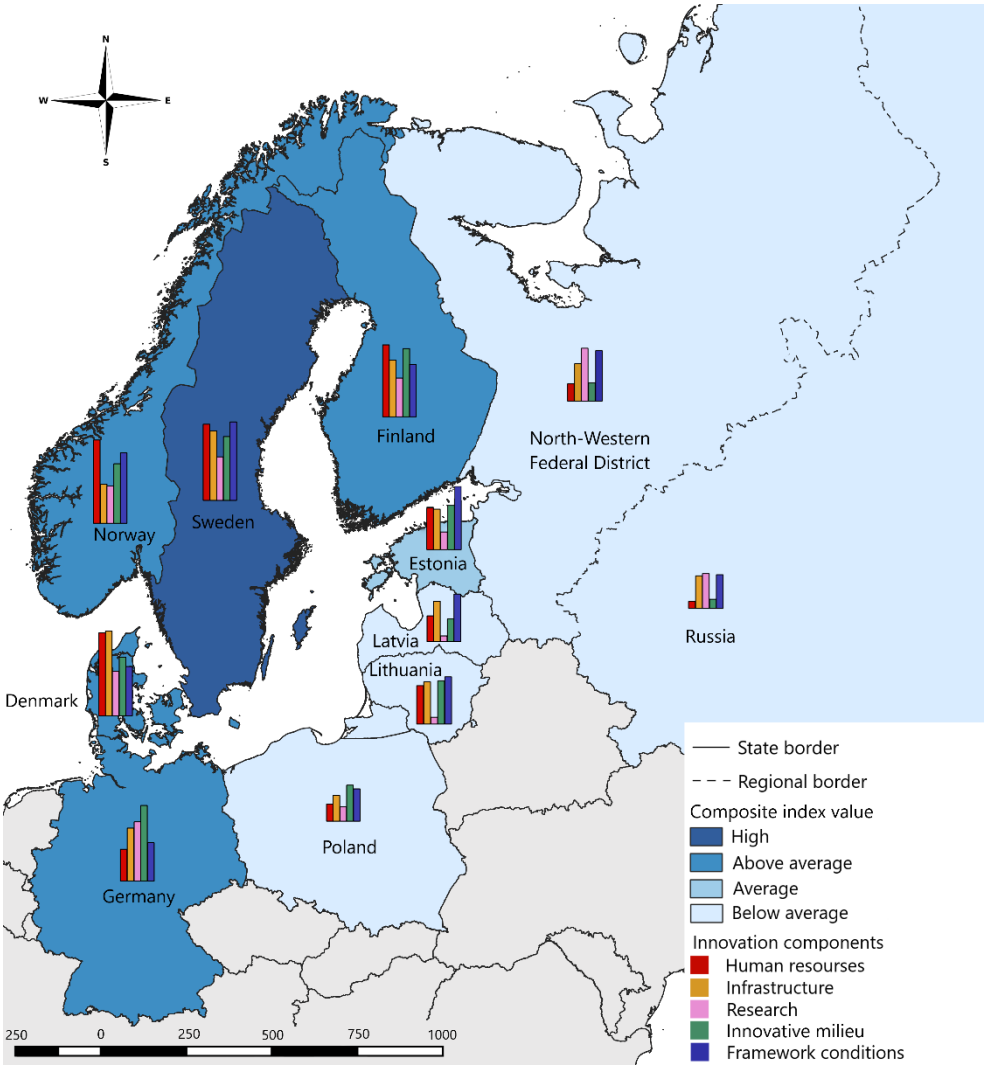
Country / region	2012	2013	2014	2015	2016	2017	Growth, % 2012-2017
High value							
Sweden	0.674	0.704	0.713	0.707	0.715	0.737	9.4
Above average value							
Denmark	0.612	0.609	0.621	0.624	0.691	0.713	16.5
Norway	0.504	0.532	0.573	0.614	0.667	0.657	30.4
Finland	0.646	0.666	0.652	0.641	0.659	0.651	0.8
Germany	0.560	0.572	0.575	0.590	0.590	0.591	5.4
Average value							
Estonia	0.463	0.448	0.414	0.420	0.459	0.462	-0.2
Below average value							
Lithuania	0.263	0.307	0.349	0.367	0.393	0.402	53.1
NWFD	0.277	0.317	0.325	0.324	0.325	0.381	37.4
Latvia	0.272	0.301	0.326	0.313	0.326	0.317	16.3
Poland	0.230	0.242	0.252	0.262	0.288	0.294	28.1
Russia	0.162	0.196	0.198	0.197	0.223	0.254	56.3

(*Source:* the authors own contribution)

The structure of the composite index in the context of the components of the territorial innovation system is given in Fig. 2.

In the study period (2012-2017), a high composite index of the territorial innovation system capacity with positive dynamics is registered in Sweden. The average composite index for six years amounted to 0.708, which is 1.6 times higher the average for the Baltic region, and 3.5 times than the lowest indicator registered for Russia. Sweden has demonstrated the most comprehensive and stable development of its territorial innovation system. High values of sub-indices are found for 4 out of 5 components – all but research component. The following are the strengths of the Swedish innovative milieu: a high proportion of personnel engaged in R&D (2.7% of EAP on average over 6 years); a significant amount of public expenditure on education and science (over 7.5 and 3% of GDP, respectively); high provision with venture capital investments (1.7 times higher than the average for the Baltic region); a developed service sector, standing for 65% of GDP; a fairly widespread dissemination of information and communication technologies (ICT) – 94% of households have Internet access and 91% of companies have a website; significant business interest is found in conducting innovative activities (over 55% of all R&D is funded by the business sector and over half of business entities are involved in innovation activity); the highest concentration of small and medium-sized businesses in the macro-region – 702 enterprises per 10,000 people in 2017.

Figure 2. Composite index of the territorial innovation systems capacity by components, 2017



(Source: the authors own contribution)

Denmark, Norway, Finland, Germany also have a rather high value of the integrated assessment of the composite index (Table 2). However, in the period of 2012-2017, these countries were not able to fully realize the potential of their territorial innovation systems, including due to their less coherent development (Fig. 2). Denmark and Finland have the most highly developed HR, infrastructure and innovative milieu components. In Norway, the HR, innovative milieu and framework conditions are most developed, while in Germany these are infrastructure, research, and innovative milieu components.

Denmark occupies a leading position in the Baltic region in terms of personnel engaged in R&D in the total number of EAP – 3.1% (2017), the public expenditure on education – 8.8% of GDP (2017); the volume of venture investments and the service sector – 0.1 and 65% of GDP; the Internet access for households – 97%. Denmark also has high levels of population education (39% with higher education with a maximum of 43.6%), the presence of companies on the Internet (95% of organizations in the business sector have a website with a maximum of 96%), and R&D funding, including the contribution of the business sector (domestic R&D expenditures – 3% of GDP, of which the share of business expenditure is 58.5%).

Finland has a similar structural development of the innovation system with Denmark, however, it is inferior in terms of individual indicators. In 2017, as compared to Denmark, Finland had a 2.5 times lower level of venture financing; 1.3 times lower level of government expenditure on education; 1.1 times – the proportion of the number of personnel engaged in R&D as of EAP, the volume of the service sector and the internal cost of R&D on GDP. The strengths of the Finnish innovation system should be noted, firstly, its high level of digitalization (96% of companies have a website and 94.4% of households have Internet access), secondly, significant human capital (42% of the population with higher education), and thirdly, a fairly high business innovation (almost 65% of all companies are innovative, and in the field of industrial production more than 55% of goods and services are innovative).

Germany maintains a fairly stable position in the Baltic region in terms of the potential of its innovation system, demonstrating a modest 5% increase in the composite index (Table 2). A distinctive feature of the German territorial innovation system is a strong research component, supported by appropriate infrastructure and a favorable innovation environment (Fig. 2). Germany has one of the highest rates of R&D funding (more than 3%) and patenting of inventions (8.2 patent applications for inventions filed by residents at WIPO, per 10 thousand inhabitants). A significant interest in innovation has formed among the economic entities of the country: the average innovative activity of organizations in 2012-2017 was at the level of 65%, and the average volume of innovative goods delivered, work performed, and services rendered of industrial production organizations was at the level of 72%. More than 65% of all internal R&D costs are covered by business entities.

Norway is an interesting case, which in 2012-2017 was able to advance among the countries of the Baltic region in terms of its innovation system capacity from 5th to 3rd place, overtaking Finland and Germany. The composite index growth by 30.4% is comparable with dynamically developing Lithuania, Poland and Russia (Table 2). Norway is the only innovatively developed country that fell into the group with a composite index higher than the average for the Baltic region, which was able to show such an active capacity building of its territorial innovation system. The largest increase in the research period was noted by indicators: innovation milieu (innovation activity of organizations grew by 58.8%,

and the share of innovative goods, work, services in the total volume grew by 33.8%), research component (R&D expenditure in GDP grew by 29% and the number of patent applications for inventions in WIPO – by 24.9%), the HR component (government expenditure on education in GDP increased by 23.3% and the number of personnel engaged in R&D to the total number of EAP increased by 18.2%).

Estonia had an average level of the composite index of a territorial innovation system capacity in the Baltic region (0.444 value over 6 years), the largest contribution to the formation of which was made by the components of HR, infrastructure, innovation milieu and framework conditions. The country has relatively high indicators of the volume of investments in fixed assets (24.4% of GDP) and SMEs (535 micro, small and medium enterprises per 10 thousand people) for the Baltic countries. The least developed is the research component of the national innovation system, including due to the annual reduction in government expenditure on science and education, which by 2017 amounted to less than 1.5% of GDP, the low volume of patenting and publication activity in international databases (including Scopus). In general, Estonia is characterized by the unfolding of a negative trend of reducing the financing of its innovation system in 2012-2017: venture investment relative to GDP decreased by 81%, investment in fixed assets by 14.5%, and the share of the business sector R&D expenditure by 6%.

The territorial innovation systems of Lithuania, Latvia, Poland, and Russia are characterized by the lowest level of accumulated potential in the Baltic region, but more active dynamics of its development (Table 2). Structurally, these countries have significant differences in the balance of their innovation systems. The most comprehensive development is registered by the innovation system of Lithuania, and the least of Latvia. Common to the innovation systems of Lithuania, Latvia, Poland and Russia are dominance in the development of the infrastructure component and framework conditions. Lithuania and Poland also have good (above average) indicators of the innovative milieu, while Russia has a strong research component. When comparing Lithuania, Latvia, Poland, and Russia with each other according to individual indicators of territorial innovation system capacity, we found the strengths of each of them in the context of all five components. The largest human potential among the countries of this group has been accumulated in Lithuania, where over 40% of the population have higher education and 1.5% of EAP are engaged in R&D. At the same time, Latvia has the highest level of government expenditure on education among these countries – 4.7% of GDP in 2017. In terms of the infrastructure component, Russia occupies a leading position in terms of venture investment indicator (0.02% of GDP), Latvia – in the scope of the service sector (64.5%), and Lithuania – in the share of business entities represented on the Internet (78%). The leading positions in the development of the research component belong to Russia, which with a similarly low share of domestic R&D expenditure from GDP (about 1%) generates a significantly larger volume of articles in Scopus and patent

applications for inventions. However, Russia is inferior to the Baltic countries and Poland in terms of the most important indicators of an innovative economy: the share of business sector expenditure on R&D (32% versus 53% for the Polish leader); the level of innovation activity of companies (8.5% versus 50.5 in Lithuania); the volume of innovative industrial products (6.7% versus 46.2% in Lithuania). The framework conditions for conducting innovative activities in Lithuania, Latvia, Poland, and Russia differ in the level of entrepreneurial activity of the population (the largest in Lithuania and Latvia), the availability of ICT for the population (leader – Poland), investment in fixed assets (leader – Russia).

The innovation system of the NWFD of the Russian Federation in the period under review has a significantly higher potential than Russia as a whole (Table 2). The Federal District, having significant accumulated research potential (similar to the level of innovatively developed countries of the macro-region, and sometimes even surpassing them) and comparatively better indicators of the framework conditions than in Russia as a whole, could not fully realize these advantages in other components of the territorial innovation system, primarily in the innovative milieu (Fig. 2).

4. Discussion

The analysis of the dynamics and structure of the composite index resulted in the identification of reserves for building the capacity of territorial innovation systems for each of the countries of the Baltic region. Consideration of the results obtained in the development and implementation of mechanisms and tools of the national innovation policy will overcome bottlenecks in the functioning of innovation systems and increase the competitiveness of countries in the innovation space of the macro-region. For countries with a composite index level of high and above the average for the Baltic region, the main recommendation is to increase the productivity of science and strengthen its ties with the business sector. For the northern countries (Sweden, Denmark, Finland, Norway) a paradox is characteristic when a large amount of funding for R&D does not result in the increased generation of innovations.

For Sweden, a significant reserve for the growth of innovative capacity is associated with the stimulation of the publication and patent activity of researchers. Currently, in Sweden, the average number of articles in the Scopus database per 1 researcher and patent applications for inventions filed by residents at WIPO per 10 thousand inhabitants are almost 3 times lower than the maximum level in the Baltic region, while as the level of domestic spending on R&D is the highest among the analyzed countries (3.4% of GDP), which indicates a reduced productivity of the scientific sector – the main generator of new knowledge.

Drivers of innovative growth for Denmark and Finland may be the development of a research component in combination with the improvement of the framework conditions for conducting innovative activities: special attention should be paid to stimulating the effectiveness of science in the form of

publications and patents for inventions, entrepreneurial activity of the population, and attracting investments in fixed assets.

In the structure of the German innovation system, the growth potential is hidden in the human resource component and the framework conditions for the flow of innovative processes. The development of the HR component, primarily, is associated with an increase in government expenditure on education and an increase in the level of education of the population, and framework conditions – with an increase in the share of small and medium-sized enterprises.

For Norway, an important factor will be the development of the infrastructure and research components of the territorial innovation system, including through promoting the expansion of the venture financing system, increasing the contribution of the services sector to GDP, transforming the results of scientific activities into patents and high-quality articles.

For countries with an average and below average values of composite index in the Baltic region the main recommendation is to increase the homogeneity of the development of their territorial innovation systems. While in most cases their development is fragmented, the drivers are one or two components. However, the effective flow of innovative processes requires the cumulative use of all the country's resources: intellectual, infrastructure, scientific, entrepreneurial, economic. Another common problem is the low level of funding for R&D and education.

The sources of growth for Estonia and Lithuania are to promote the development of the research component of the innovation system, primarily by increasing government expenditure on science and education, promoting scientific productivity (the growth of new knowledge) and increasing collaboration with scientists from other countries to implement research projects in view of small internal academic capacity.

Latvia needs to focus on the integrated development of all the components of the innovation system, first of all, supporting national science and its human resources. The country has one of the lowest levels of funding for internal R&D in comparison with other countries of the Baltic region – an average of 0.59% of GDP with a downward trend over the 2012-2017 period, and the number of personnel engaged in R&D in the total economically active population is 1.1%. With that, multidirectional dynamics should be noted: an increase in the number of publications in Scopus along with a reduction in the filing of patents in WIPO for inventions.

Poland is characterized by problems similar to the Baltic states associated with underfunded science and education systems, low indicators of publication and patent activity. In addition, the level of innovation activity among business entities is also quite low (22%), it is necessary to involve SMEs in innovative processes, to promote their interest in introducing innovations and producing innovative products. In 2017, Poland lagged behind the leaders of the macro-region in the level of innovative activity of organizations by 3.2 times, the share of innovative goods produced, work performed, services rendered by 1.9 times and the level of investment in fixed assets of GDP by 1.6 times.

Assessment of the place of Russia and its subregion in the Baltic region – the NWFD, according to the level of innovation system capacity yielded different results, showing the great heterogeneity of individual territories of the Russian Federation in innovative development. Due to the location of St. Petersburg in it, the NWFD is a large scientific center, which is reflected in the high values of the index for the research component. However, despite a higher level of development of science than the average for Russia and many countries of the macro-region, the innovation system of the Northwestern Federal District – part of the national innovation system of Russia, is characterized by the same structural problems: low business involvement in innovation processes, lack of an effective system for generating new scientific knowledge for innovation, insufficient level of development of information and communication infrastructure and the degree of informatization, underfunded science. Assistance in building ties between business and academia, incl. an increase in the contribution of the business sector to the financing of research, and the digitalization of the economy are important factors for further growth for the Russian Federation in relation to the NWFD.

Conclusions

Innovation is the foundation of long-term competitiveness. Countries that more actively accumulate their innovative capacity and use it more efficiently will lead the competition for resources. A significant number of factors affect the innovation process, therefore, its effectiveness depends on the complexity of governing all the components of the territorial innovation system. It is necessary to established linkages and develop coherence in the functioning of individual innovation components: human resources, infrastructure, research, innovative milieu, and framework conditions. Scandinavian countries (Sweden, Denmark, Norway, Finland) and Germany – the leaders of the ranking, have achieved the highest efficiency of their internal resources by implementing an integrated development scheme. While having moderate share of GDP dedicated to R&D expenditure, they have managed to established the favorable environment within the territorial innovation systems for private sector R&D. The Baltic countries, Poland and Russia show an intensive capacity growth of their innovation systems. Intensified competition for knowledge and innovation makes it necessary for all countries to constantly monitor their strengths and weaknesses in innovative development and elaborate sophisticated innovation policies. A significant capacity of innovative growth is found in the implementation of joint research and entrepreneurial collaborations aimed at generating new knowledge and innovations.

Our integrated assessment of territorial (national and regional) innovation systems and analysis of their individual structural components suggest a strong divergence of the Baltic region. The innovation capacity of individual territories can excel the national values, thus, being the desirable collaboration partner in innovation-intensive initiatives. We believe that country-region assessment of territorial innovation capacity should be employed for increasing the efficiency of

development strategies within an international (cross-border, trans-marine) domain of macro-regions.

Authors Contributions

The authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

Conflict of Interest Statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Acknowledgement

The reported study was funded by RFBR according to the research project № 19-010-01083 "Problems of Innovation Security and Mechanisms of Cluster Economic Development of the Border Regions of the European Part of Russia" (recipient Andrey Mikhaylov). Data collection is done by Oksana Savchina, whose participation is supported by the "RUDN University Program 5-100".

References

Booysen, F. (2002). An overview and evaluation of composite indices of development. *Social Indicators Research*, 59(2), pp. 115-151.

Barmuta, K.; Ponkratov, V.; Maramygin, M.; Kuznetsov, N.; Ivlev, V.; Ivleva, M. (2019). Mathematical model of optimizing the balance sheet structure of the Russian banking system with allowance for the foreign exchange risk levels, *Entrepreneurship and Sustainability Issues* 7(1), 484-497. http://doi.org/10.9770/jesi.2019.7.1(34)

Breschi, S., Lissoni, F. (2001). Knowledge spillovers and local innovation systems: a critical survey. *Industrial and Corporate Change*, 10(4), pp. 975-1005. DOI: http://dx.doi.org/10.1093/icc/10.4.975

Caragliu, A., Nijkamp, P. (2016). Space and knowledge spillovers in European regions: the impact of different forms of proximity on spatial knowledge diffusion. *Journal of Economic Geography*, 16(3), pp. 749-774. DOI: http://dx.doi.org/10.1093/jeg/lbv042

Carayannis, E., Provance, M. (2008). Measuring firm innovativeness: Towards a composite innovation index built on firm innovative posture, propensity and performance attributes. *International Journal of Innovation and Regional Development*, 1(1), pp. 90-107.

Carayannis, E.G., Campbell, D.F.J. (2009). 'Mode 3' and 'Quadruple Helix': Toward a 21st century fractal innovation ecosystem. *International Journal of Technology Management*, 46 (3-4), pp. 201-234.

Carlsson, B., Stankiewicz, R. (1991). On the nature, function and composition of technological systems. *Journal of Evolutionary Economics*, 1, pp. 93-118.

Coad, A., Rao, R. (2008). Innovation and firm growth in high-tech sectors: A quantile regression approach. *Research Policy*, 37(4), 633-648.

Cojanu, V., Robu, R. (2019). The geography of territorial capital in the European union: A map and several policy issues. *Transylvanian Review of Administrative Sciences*, 15(56), pp. 23-40.

Gackstatter, S., Kotzemir, M., Meissner, D. (2014). Building an innovation-driven economy - the case of BRIC and GCC countries. *Foresight*, 16(4), pp. 293-308.

Iammarino, S. (2005). An evolutionary integrated view of Regional Systems of Innovation: Concepts, measures and historical perspectives. *European Planning Studies*, 13(4), pp. 497-519. DOI: http://dx.doi.org/ 10.1080/09654310500107084

Lundvall, B.A., & Johnson, B. (1994). The learning economy. *Journal of Industry Studies*, 1(2), pp. 23-42. DOI: http://dx.doi.org/10.1080/ 13662719400000002

Makkonen, T., Van der Have, R.P. (2013). Benchmarking regional innovative performance: Composite measures and direct innovation counts. *Scientometrics*, 94 (1), pp. 247-262.

Moris, F., Jankowski, J., & Perrolle, P. (2008). Advancing measures of innovation in the United States. *Journal of Technology Transfer*, 33(2), pp. 123-130.

OECD (1996). The knowledge-based economy. Science, Technology and Industry Outlook, Paris: OECD.

OECD (2005). Oslo manual: Proposed guidelines for collecting and interpreting technological innovation data. Paris: OECD.

Ohanyan G., Androniceanu, A**.** (2017). Evaluation of IMF program effects on employment in the EU, *Acta Oeconomica*, 67(3), 311-332

Osipov, G.; Ponkratov, V.; Karepova, S.; Bloshenko, T.; Vorontcov, A. (2019). Transit tariff optimization model for Russia and Central Asia energy cooperation, *Entrepreneurship and Sustainability Issues*, 7(1), 398-412. http://doi.org/10.9770/jesi.2019.7.1(28)

Serrano-Bedia, A. M., López-Fernández, M. C., & García-Piqueres, G. (2018). Complementarity between innovation knowledge sources: Does the innovation performance measure matter? *BRQ Business Research Quarterly*, 21(1), pp. 53-67. DOI: http://dx.doi.org/10.1016/ j.brq.2017.09.001

Storper, M. (1995). The resurgence of the regional economies ten years later: the region as a nexus of untraded interdependencies. *European Urban and Regional Studies*, 2(3), pp. 191-215. DOI: http://dx.doi.org/10.1177/ 096977649500200301

Tang, J., Le, C. (2007). Multidimensional innovation and productivity. *Economics of Innovation and New Technology*, 16(7), pp. 501-516.

Voloshenko, K. Yu., Mikhailova, A. A. (2013). Russian scientific and technological potential in comparison with other countries of the Baltic region. The potential of interaction between Russia and the EU in the innovative sphere in the Baltic, Publisher: IKBFU. pp. 26-67.