

# SPATIO-TEMPORAL PATTERNS OF KNOWLEDGE TRANSFER IN THE BORDERLAND

A. S. Mikhaylov <sup>a</sup>

J. A. Wendt <sup>b</sup>

I. Yu. Peker <sup>a</sup>

A. A. Mikhaylova <sup>a</sup>

<sup>a</sup> Immanuel Kant Baltic Federal University  
14, A. Nevskogo St., Kaliningrad, Russia, 236016

<sup>b</sup> University of Gdansk  
4 Jana Bażyńskiego Str., Gdańsk, Poland, 80–309

Received 05 September 2019

doi: 10.5922/2079-8555-2020-1-8

© Mikhaylov A. S., Wendt J. A.,  
Peker I. Yu., Mikhaylova A. A., 2020

*A key competitive advantage of a contemporary economy, knowledge, is distributed unevenly, tending to concentrate in cities and urban agglomerations. A border position translates into distinctive features of regional innovative development. In a favourable institutional context, proximity to a border strengthens transboundary cooperation and interaction between neighbouring regions. Although frequent social contacts across borders are well documented in the literature, the effect that the border has on intensive knowledge transfer is yet to be investigated. This article analyses models of knowledge integration taking place between Russia's northwestern regions and the countries that their border. The study covers six territories of the Northwestern federal district (the Republic of Karelia, St Petersburg, and the Kaliningrad, Leningrad, Murmansk, and Pskov regions); five regions of the Central federal district (Belgorod, Bryansk, Voronezh, Kursk, and Smolensk); and one region of the Southern federal district (Rostov). The methodology of the study consists of using information from the Scopus abstract and citation database to assess the intensity of research cooperation. The findings suggest that the degree of involvement in transboundary research cooperation varies widely across Russia's border regions.*

## **Keywords:**

knowledge geography, border region, borderland, knowledge transfer, cross-border cooperation, Baltic region

## **Introduction**

Literature offers two opposite views on the innovative development of border areas and their contribution to the national innovation system (NIS).

On the one hand, border areas are often considered as peripheral or even marginal in terms of economic, socio-economic and innovative development

**To cite this article:** Mikhaylov, A. S., Wendt, J. A., Peker, I. Yu., Mikhaylova, A. A. 2020, Spatio-temporal patterns of knowledge transfer in the borderland, *Balt. Reg.*, Vol. 12, no 1, p. 132–155. doi: 10.5922/2078-8555-2020-1-8.

[1–7]. Most international [2; 8] and Russian [9–10] studies on regional divergence confirm the asymmetric distribution of innovative potential and classify borderlands as the periphery or catching-up, depressed, and lagging-behind regions. Research, technological, innovation, and related infrastructure develop slowly in border areas [11–12]. The density of innovation-active organisations [13–15] is low there; the local sales market is narrow [18]; the institutional environment is unstable and highly dependent on geopolitical and macroeconomic fluctuations [20–21]. All this predetermines a focus on producing incremental (secondary or complementary) innovations. Findings point to that the spatial capital of these regions is limited and their influence on the national innovative landscape is insignificant.

On the other hand, border regions are natural contact zones that interact with elements of the spatial socio-economic and innovation systems of neighbouring states. These areas can be considered as strategic development corridors. Andrey Klemeshev and Gennady Fedorov [22–23] emphasise that border areas have a major role in developing bilateral (Russia–EU) international innovation flows. The contact function of the state border manifests itself in the intensity of movement of material goods (commodities, services, capital), people, and intellectual capital (knowledge, culture, competencies). This function is also essential for international ties [24]. Neighbouring regions of two countries are usually quite close in socio-cultural and institutional terms. This kinship creates a favourable environment for stable cross-country cooperation and enhances the ability to embrace new knowledge and disseminate it nationwide, as well as to adapt it to local conditions) [25]. Stronger integration between neighbouring regions of two countries helps to accumulate a critical mass of participants in innovations to ensure competitiveness at national (NIS) and global level. Researchers have described many cases of successful transboundary regionalisation of innovative systems of border areas in Europe. These examples include transboundary clusters: Øresund between Denmark and Sweden [26–29], the Alsace BioValley between France, Germany, and Sweden [30], and others. According to [31–32], transboundary regionalisation is a strategic priority in developing the regional innovation systems (RIS) of border areas: regionalisation makes it possible to change dramatically the existing development trajectory and shift the balance of the centre-periphery model of innovation production.

The duality of research findings precludes a conclusive answer to the question about the role and place of border regions in developing the NIS. In particular, researchers have stressed the need for devising a new approach to evaluating the innovative performance of border areas. This new technique should take into account indicators other than the critical mass, network density, and their likes used in studying central regions [33]. In this article, we seek to provide a comprehensive evaluation of the intensity of transboundary research cooperation involv-

ing Russia's western borderlands. Concentrating on one RIS component makes it possible to measure the engagement of local actors in cross-country networking, evaluate the quality of intellectual collaborations, understand the localisation of interacting parties, and identify the role of the geographical factor in the distribution of knowledge-intensive activities. Special attention is paid to the potential for strengthening transboundary cooperation and integration. To this end, we analyse the unilateral use of research findings by international academics. The key hypothesis of our study is that most of the potential of the RIS research component remains untapped in the states bordering Russia to the east.

### **Literature review**

---

The internationalisation of research is a result of the growing trend for innovation processes to become more complicated and for R&D to accelerate. To an extent, these processes are a result of the shrinking product lifecycle and commercialisation period. In an open market when information on the potential of possible counterparties is widely available, the role of effective management of innovation processes aimed at developing and introducing complementary 'value propositions' is increasing [34–36]. State-of-the-art hi-tech infrastructure including laboratory and experimental facilities, top specialist and the ability to recruit and train them, as well as business and intellectual excellence may contribute to transboundary research cooperation. How much international partners are *committed* to forging partnerships with regional actors depends directly on the expected synergistic effect, the presence of which indicates a significant increase in efficiency. Despite geographical proximity, the research components of a border area RIS can be so unlike that the complementarity of key strategic development areas is impossible [37–38]. At the same time, absolute compatibility, which means identical infrastructure as well as similar competences and challenges, makes cooperation less attractive an option. Research cooperation between border region agents requires that they should be at a similar level of development as regards the range of complementary competencies in question (particularly, in terms of disciplinary micro-specialisations), explore similar problems, and share a common research paradigm. According to [39], similar approaches and technology ensure the transfer of knowledge between collaborating parties. Wesley M. Cohen and Daniel A. Levinthal [40] emphasise that the success of cooperation is largely determined by the capacity of the parties to absorb newly acquired information. Key to their concept is prior related knowledge, which is transferred through direct personal contacts. It includes experience, skills, abilities, know-how, and processes. Here, confidence in results is crucial for a decision to cooperate. A major consideration is thus the *quality* of current findings and their prospects for implementation in joint projects.

In the research community, *Quality* is closely linked to the elusive category of academic reputation.<sup>1</sup> At the same time, an additional and commonly recognised quality criterion is the status of research periodicals where a university's employees publish their findings. The Web of Science international citation database uses the impact factor indicator, the Scopus counterpart of which is CiteScore<sup>2</sup>. The literature has confirmed that findings from international collaborations are associated with higher quality than those from national ones are [41–43].

As the geography of cooperation network expands, the cost of maintaining permanent contacts increases. For instance, André Torre [44–45] writes that information and communications technology meet the need for personal communication only partially and cannot replace it completely. Temporal geographical proximity, which is achieved through working meetings, roundtables, conferences, etc., does not ensure the level of engagement necessary for innovative collaborations, particularly, the generation of new basic knowledge. Only quality results that significantly boost average values ensure return on investment in a cooperation network (finances, time, intellectual efforts, labour, etc.).

The degree of *engagement* of a wide range of stakeholders on either side of the border in the joint process of knowledge generation describes the development of network ties. The stability of a transboundary RIS (TRIS) is ensured by a pool of various interacting parties committed to long-term cooperation with a prospect of delegating part of equally significant functions to international partners, including laboratory tests, design and engineering, software development, etc. Accumulating a critical mass of participants in a transboundary cooperation network facilitates devising a coordinated and prospectively common development strategy. It covers, as a rule, investment policy, promising projects, technical and operational harmonisation, and qualification requirements (KPI, working conditions, etc.). The proportion of researchers involved in networking reflects the weight given to the area of cooperation in question and readiness to develop it. An important factor is a favourable institutional environment that can help to streamline transboundary contacts by simplifying the visa regime, modernising the road network and border-crossing infrastructure, enhancing passenger communications, etc. Since trust is a sine qua non of R&D collaborations [46–47], socio-cultural projects and joint non-profit organisations have a significant role in the emergence of a TRIS. A major obstacle, however, is the institutional

---

<sup>1</sup> Two out of three major university rankings (QS World university ranking and the Times Higher Education World university ranking) poll research and academic staff to identify the most authoritative research and educational institutions.

<sup>2</sup> The impact factor indicator (Web of Science) represents the citation rate over two years after publication for an average article in a given journal. Although CiteScore (Scopus) is a derivative of the impact factor, it is calculated for a citation window of three years.

context, which is largely a product of the geopolitical situation. A good environment for bilateral contact between regions of two countries translates into the natural comfort of cooperation.

Geographical proximity facilitates frequent social contacts between the members of the research subsystem of a TRIS. Empirical findings suggest that the density of intra-network contacts depends on geographical remoteness [48]. *Localisation* and later clustering create a favourable background for mutual education and knowledge spillover supported by informal personal communication [49–53]. Geographical closeness contributes enormously to stronger informal ties [52; 54], trust, recognition of belonging [50; 51; 52], easier information exchange and access to various types of knowledge [55], as well as the solidarity of like-minded individuals and a common identity [53].

## **Methodology**

Methodologically, this study draws on approaches used in contemporary scientometrics and analyses a vast array of bibliometric data. This way, it becomes possible to get an idea of the dynamics of transboundary research cooperation. We analysed twelve Russian border regions, six of them in the Northwestern federal district (NWFD) (the Republic of Karelia, the Kaliningrad, Leningrad, Murmansk, and Pskov regions, and St Petersburg); five in the Central federal district (CFO) (the Belgorod, Bryansk, Voronezh, Kursk and Smolensk regions); one in the Southern federal district (SFD) (the Rostov district). These territories are grouped according to bilateral transboundary ties with the border regions of neighbouring countries (Belarus, Latvia, Lithuania, Norway, Poland, Ukraine, Finland, Estonia):

### NWFD:

Republic of Karelia (Finland),  
Kaliningrad region (Poland, Lithuania),  
Leningrad region (Finland, Estonia),  
Murmansk region (Finland, Norway),  
Pskov region (Belarus, Latvia, Estonia),

St Petersburg (Finland, Estonia) (the St Petersburg agglomeration is included in the list as an active player in transboundary relations);

### CFO:

Belgorod region (Ukraine),  
Bryansk region (Belarus, Ukraine),  
Voronezh region (Ukraine),  
Kursk region (Ukraine),  
Smolensk region (Belarus),

### SFO:

Rostov region (Ukraine).

The source of the bibliometric data used in our analysis is Socpus — the largest international citation database, which covers findings distributed by over 5000 publishing houses worldwide, including Elsevier, Springer-Nature, Wiley, Taylor & Francis, Sage, and others. We analyse six-year-data (2013–2018). The list of indicators includes the number of publications with international co-authors, the total number of authoring teams, and the citation rate (with the field-weighted citation impact, FWCI, taken into account). The latter measure helps to compare the number of publications across different fields of knowledge.

We searched Scopus for research publications, using the following advanced search queries (those below are for the Kaliningrad region (Russia) — Poland pair):

*“AFFILCOUNTRY (Russia\*) AND AFFILCITY (“Kaliningrad”) OR AFFILCITY (“Bagratiouovsk”) OR AFFILCITY (“Guryevsk”) OR AFFILCITY (“Gusev”) OR AFFILCITY (“Zelenogradsk”) OR (AF-ID (“Immanuel Kant Baltic Federal University” 60031254) OR AF-ID (“Kaliningrad State Technical University” 60018744)) AND (LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015) OR LIMIT-TO (PUBYEAR, 2014) OR LIMIT-TO (PUBYEAR, 2013)) AND (LIMIT-TO (AFFILCOUNTRY, “Poland”))*

The search query for each Russian regions included all publishing cities and towns and the names of all research and educational institutions. The resultant publication pool was exported into the SciVal analytics tool for a detailed analysis of international partner organisations. On the list of analysed measures are the organisation types (an institute of an academy of sciences, a university, a commercial organisation, other), as well as the region and the city/town where this organisation was located.

Data processing consisted of three key stages.

Stage 1: using the information on the current network of research cooperation, a pattern of current interregional cooperation was established and the intensity of ties in the border area identified. To this end, network relations were built between cities. The intensity of these relations was characterised by the volume of co-authored publications and the total number of authoring teams.

Stage 2: based on an analysis of works citing the findings of Russian researcher, potential cooperation channels were identified. At this stage, the analysis covered all research centres that did not carry out joint research over the reporting period but benefitted from the intellectual results of Russian authors.

Stage 3: a transboundary research cooperation index was calculated using four subindices:

*Subindex 1: engagement.* This index comprised the following measures: X1, the ratio of joint publication authors from a neighbouring country to the country’s organisations listed in affiliation; X2, joint publications with authors from

a Russian border region as a proportion of all publications of the neighbouring country's research centres that have at least one joint publication with a research centre in the Russian region.

*Subindex 2: commitment.* This index consisted of the following measures: X3, the ratio of citations of a publication from a Russian region by researchers from a neighbouring country to all research publications in the neighbouring country; X4, the ratio of researchers from a neighbouring country, citing publications from the Russian region, to all researchers from the citing organisations in the neighbouring country.

*Subindex 3: quality.* This index covers the following measures: X5, citations to publications co-authored by researchers from a Russian region and the neighbouring country (citations per paper); X6, the average FWCI of publications co-authored by researchers from a Russian region and the neighbouring country.

*Subindex 4: localisation.* This index is based on the following measures: X7, the ratio of cities where the research centres of affiliation of neighbouring country's co-authors are situated to all borderland cities that are home to universities; X8, the ratio of organisations of affiliation of a neighbouring country's co-authors to all research centres in that country.

The measures were normalised by linear scaling to the range [0; 1], where 0 is the minimum and 1 the maximum attribute value. The initial data normalisation formula for the measures of positive attributes is as follows:

$$Z_{ij} = \frac{a_{ij} - a_j^{\min}}{a_j^{\max} - a_j^{\min}}, \text{ provided } a_j^{\max} \neq a_j^{\min}, \quad (1)$$

where  $Z_{ij}$  is the normalised value of the  $j^{\text{th}}$  measure for the  $i^{\text{th}}$  region;

$a_{ij}$  is the values of the  $j^{\text{th}}$  measure of the  $i^{\text{th}}$  region;

$a_j^{\max}$  is the maximum value of the  $j^{\text{th}}$  measure;

$a_j^{\min}$  the minimum value of the  $j^{\text{th}}$  measure.

The subindices and the integrated index are calculated using the arithmetic mean:

$$\overline{Z_{ij}} = \frac{\sum_{j=1}^n Z_{ij}}{n}, \quad (2)$$

where  $\overline{Z_{ij}}$  is the value of the integrated index;

$Z_{ij}$  is the normalised value of the  $j^{\text{th}}$  measure for the  $i^{\text{th}}$  region;

$n$  is the total number of measures ( $n=2$  for the subindices and  $n=4$  for the integrated index).

The validation of the measures considered within the above subindices is given in some economic-geographical studies, including those by Russian authors [56—58]. Methodological limitations include the emergence of extreme values that were excluded from calculations and the cases when no publications were cited and the FWCI was zero (such observations were not analysed further).

## Results

The total number of Russian works indexed in the Scopus international database in 2013–2018 was 447,818, which places the country 13<sup>th</sup> worldwide. The contribution of the border regions under study to the total number of publications in Russia is insignificant (Table 1).

Table 1

**The contribution of Western border regions to the array of Russian publications, 2013–2018**

Region of Russia	Contribution to publications in Russia	Proportion of publications with neighbouring countries
St Petersburg	15.40%	Finland, 4.25% (9*) Estonia, 1.29% (45)
Rostov region	1.87%	Ukraine, 1.65% (6)
Leningrad region	0.94%	Finland, 21.73% (33) Estonia, 14.55% (52)
Voronezh region	0.82%	Ukraine, 1.16% (4)
Belgorod region	0.75%	Ukraine, 8.91% (1)
Murmansk region	0.43%	Norway, 6.10% (1) Finland, 3.28% (2)
Kursk region	0.41%	Ukraine, 1.64% (3)
Kaliningrad region	0.37%	Poland, 3.51% (6) Lithuania, 2.48% (10)
Republic of Karelia	0.32%	Finland, 8.76% (1)
Bryansk region	0.14%	Belarus, 2.96% (1) Ukraine, 1.40% (9)
Smolensk region	0.09%	Belarus, 3.43% (2)
Pskov region	0.03%	Estonia, 6.34% (1) Latvia, 2.82% (2) Belarus, 2.11% (4)

*Comment:* \* ranking on the ratio of co-authored works to all regional works in 2013–2018.

Over the reporting period, 24.7% of Russian publications had international co-authors. In 2013–2018, this proportion fell from 28.5% to 22.5%. Key partners are developed countries of the West: the US, Germany, France, UK, and Italy. A similar distribution is characteristic of the dynamics of international co-authorship in Russia's border regions with varying involvement of neigh-



bouring countries in research collaborations (table 1). An examination of the top five countries by the proportion of publications co-authored by experts from a Russian region and the neighbouring state reveals differences in the internationalisation of the research component of a RIS:

— St Petersburg: Germany — 10.88%, US — 10.69%, France — 6.76%, UK — 6.66%, Italy — 5.42%.

— Rostov region: Germany — 3.24%, France — 2.81%, US — 2.49%, Italy — 2.30%, UK — 1.73%.

— Leningrad region: Germany — 63.68%, US — 61.64%, France — 53.84%, Italy — 52.75%, China — 51.56%.

— Voronezh region: Germany — 2.92%, US — 2.70%, Japan — 1.35%, Ukraine — 1.16%, Vietnam — 1.13%.

— Belgorod region: Ukraine — 8.91%, Germany — 2.69%, US — 2.40%, Poland — 1.57%, France — 1.39%.

— Murmansk region: Norway — 6.10%; Finland — 3.28%; Germany — 2.97%; UK — 2.82%; US — 2.82%.

— Kursk region: Germany — 3.12%, Kazakhstan — 1.97%, Ukraine — 1.64%, Poland — 1.09%, Denmark — 0.99%.

— Kaliningrad region: Germany — 8.83%, France — 5.74%, US — 4.78%, Spain — 4.72%, UK — 4.35%.

— Republic of Karelia: Finland — 8.76%, Sweden — 3.71%, Germany — 3.01%, US — 3.01%, Norway — 2.59%.

— Bryansk region: Belarus — 2.96%, US — 2.18%, Serbia — 2.02%, South Korea — 1.40%, Ukraine — 1.40%.

— Smolensk region: US — 4.17%, Belarus — 3.43%, UK — 3.43%, Italy — 3.43%, Germany — 2.70%.

— Pskov region: Estonia — 6.34%, Latvia — 2.82%, Sweden — 2.82%, Belarus — 2.11%, Finland — 2.11%.

St Petersburg and the Leningrad, Rostov, and Kaliningrad regions are the closest to the national pattern of international partner distribution. The Pskov region focuses on networking with neighbouring countries, albeit the total number of publications is below ten in either case.

At Stage 1 of the study, measures of the transboundary cooperation potential were analysed: the dynamics of the impact of joint studies at the city and regional levels; the demand for the knowledge capital of Russia's border regions from international partners (fig. 1, 2).

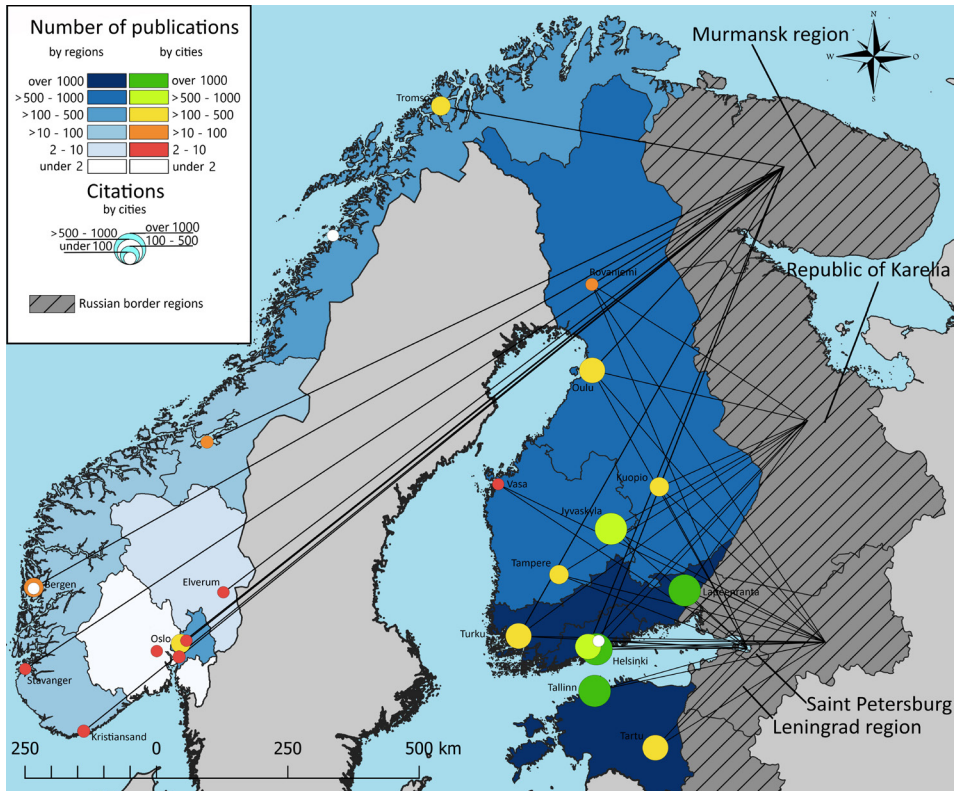


Fig. 1. Research networking between Russia’s western borderlands and neighbouring Northern European countries [59]

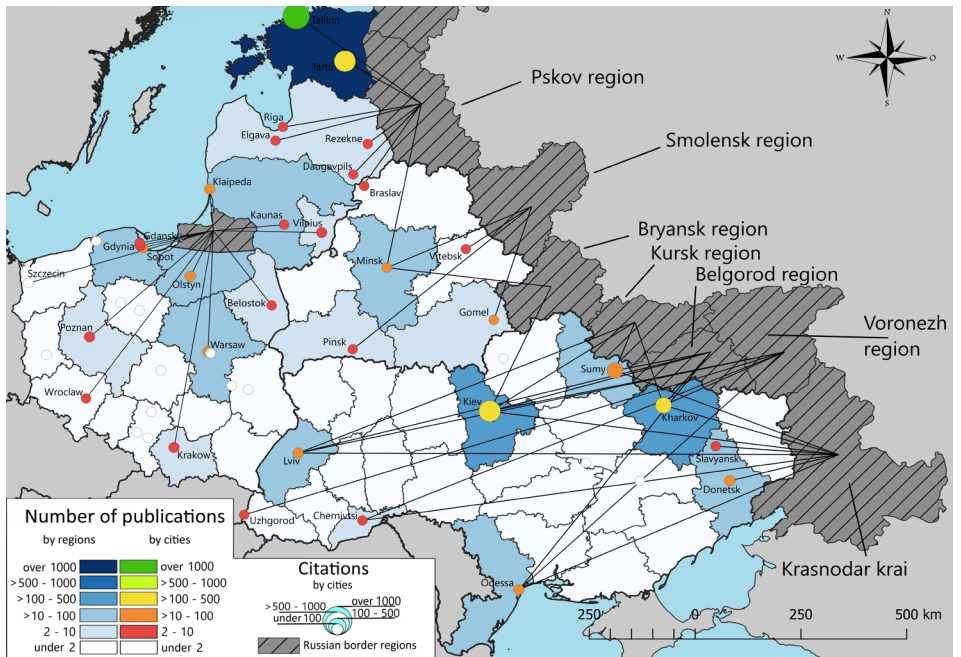


Fig. 2. Research networking between Russia’s western borderlands and neighbouring eastern European countries [59]

Based on the data on the current and potential structure of research ties, the transboundary research cooperation index was calculated (Table 2). The computation did not include regions that have fewer than ten publications with the neighbouring states: the Bryansk region–Ukraine, the Pskov region–Belarus, the Pskov region–Latvia, the Pskov region–Estonia.

Table 2

**Transboundary research cooperation index for Russia's western borderlands**

Region-of cooperation	Index	Subindex			
		I	II	III	IV
St Petersburg–Estonia	0.753	0.652	1.000	0.659	0.700
Leningrad region–Estonia	0.592	1.000	0.469	0.616	0.284
St Petersburg Finland	0.450	0.491	0.603	0.426	0.281
Leningrad region–Finland	0.291	0.468	0.119	0.533	0.045
Murmansk region–Norway	0.273	0.036	0.065	0.673	0.319
Kursk region–Ukraine	0.252	0.016	0.011	0.371	0.610
Belgorod region–Ukraine	0.251	0.088	0.102	0.296	0.519
Kaliningrad region–Lithuania	0.242	0.047	0.073	0.419	0.430
Kaliningrad region–Poland	0.227	0.007	0.008	0.515	0.380
Republic of Karelia–Finland	0.220	0.079	0.046	0.556	0.198
Murmansk region–Finland	0.217	0.032	0.027	0.685	0.124
Rostov region–Ukraine	0.214	0.037	0.055	0.242	0.522
Smolensk region–Belarus	0.179	0.012	0.000	0.080	0.624
Bryansk region–Belarus	0.164	0.021	0.010	0.028	0.598
Voronezh region–Ukraine	0.140	0.010	0.021	0.313	0.215

*Comment:* I stands for the Engagement subindex, II the Commitment subindex, III the Quality subindex, and IV the Localisation subindex.

Among the regions studied, St Petersburg and the Leningrad region are the most deeply integrated into cross-border research cooperation. Together, they constitute the largest research centre of Russia's North-West. Their transboundary research cooperation has two directions: southwestern (Estonia) and north-western (Finland). The closest research connections link St Petersburg and the Leningrad region with Estonia. For St Petersburg–Estonia and Leningrad region–Estonia, the transboundary research cooperation index reached 0.753 and 0.592 respectively in 2013–2018; the maximum value is 1. Although collaborations with Finland are less active, they are of considerable interest for the Russian border regions willing to strengthen transboundary research. Russia–Finnish partnerships develop along several channels. The most developed is St Pe-

tersburg–Finland (0.450); three others (the Leningrad region–Finland [0.291], the Republic of Karelia–Finland [0.220], and the Murmansk region–Finland [0.217]) have strong potential. Collaborations between the Murmansk region and the border areas of Norway, the Kursk and Belgorod regions and Ukraine, and the Kaliningrad region and the border areas of Lithuania and Poland also seem promising. These partnerships, however, are at their teething stage: their average value of the transboundary research cooperation index is 0.25. The weakest research integration was observed in 2013–2018 in the Russian–Ukrainian and Russian–Belarusian borderlands, which comprise the Rostov, Smolensk, Bryansk, and Voronezh regions.

Structural analysis of the index reveals how cross-border research cooperation develops in terms of engagement, commitment, quality, and localisation. Relatively high values of the I-subindex were obtained for the research centres of the Leningrad region and St Petersburg and their collaborations with Estonia and Finland. This result is explained by the significant involvement of researchers within a single organisation and a considerable proportion of joint publications (Table 2). The engagement of other Russian border regions in transboundary research cooperation is low, below 0.1. The distribution of regions according to their commitment to transboundary research cooperation (II-subindex) has a similar pattern. The leading position of St Petersburg, a major research centre whose findings are in demand from Finnish and Estonian experts, is reflected in the relative number of citations and the number of citing researchers. The Leningrad region ranks second; its ties with Estonia are stronger than they are with Finland. As to the lowest II-subindex levels, Ukraine, Poland, and Belarus are little interested in research collaborations with the Kursk, Kaliningrad, and Smolensk regions respectively. The cooperation priorities of researchers from these countries, thus, lie elsewhere.

Quality is an important measure of research cooperation of border regions. It is reflected in the recognition of and demand for research findings from international academia. In this respect, collaborations between the research centres of the Murmansk region and the border areas of Finland and Norway and between St Petersburg/the Leningrad region and Estonia rank the highest. Their III-subindex values are above 0.6. Average quality values are associated with publications prepared in collaborations between researchers from the Republic of Karelia, the Leningrad region, and St Petersburg, on the one hand, and Finland, on the other, as well as with contributions co-authored by Kaliningrad, Polish, and Lithuanian experts (Table 2). The lowest III-subindex values are characteristic of the Russian–Belarusian and vast Russian–Ukrainian borderlands. The quality of joint studies carried out in those areas is rather low by international research standards. The distribution of regions by localisation is remarkable. St Petersburg–Estonia (0.700), the Smolensk region–Belarus (0.624), the Kursk

region–Ukraine (0.610), the Bryansk region–Belarus (0.598), the Rostov region–Ukraine (0.522), and the Belgorod region–Ukraine pairs (0.519) score highly on the IV-subindex. The IV-subindex values of two cooperation areas are average (0.4). These are the Kaliningrad region–Lithuania and the Kaliningrad region–Poland. The other areas have a rather low level of transboundary research localisation.

## **Discussion and conclusions**

In this study, we examined nineteen geographical areas of transboundary research cooperation between twelve Russian border regions and eight neighbouring countries in 2013–2018. We evaluated interactions between each of the Russian regions and the neighbouring country (ies) in general, carried out a comparative analysis, and identified the most active areas of research collaborations.

Cooperation with Estonia involves three Russian regions: St Petersburg, the Leningrad region (with which the country has forged stable transboundary ties), and the Pskov region (it had only nine joint publications over the studied period). Although the number of Estonian research centres whose experts publish their findings in Scopus-indexed periodicals (seventy-four) is rather small, most of them cooperate with their counterparts from Russian borderlands, primarily, St Petersburg (10.8%). The geographical scope of the Leningrad region–Estonia partner network is smaller. The level of engagement, however, is one-third higher than that in St Petersburg, being the highest among all the research cooperation areas considered in this article. According to the quality and commitment subindices, research cooperation in the Russian–Estonian borderlands is valued by both parties, whereas its outcomes meet high standards.

The above is explained by stronger contacts in biomedicine, which is a traditional research area for Estonia [60] and a current strategic priority for both countries. Key research partners from Estonia are the National Institution of Chemical Physics and Biophysics (Tallinn) and the University of Tartu. The latter is home to the Estonian Biocentre, which was established in the Soviet period. Today, Estonia is one of the few countries in the world that has a successfully functioning genome biobank. In 2015, with financial support from the Russian Science Foundation, St Petersburg State University (SPSU) launched the project to create the first Russian biobank — a dedicated cryostorage for biological materials and a clinical laboratory for biomedical studies in health and longevity. Alongside the key Estonian Universities, Tallinn University, Tallinn University of Technology, and the Estonian University of Life Sciences, the partnership involves the National Institute for Health Development, which con-

ducts population studies in healthcare. The St Petersburg agglomeration is a strong research centre that has attracted considerable resources from across the country, including those of Russia's leading universities topping international rankings (St Petersburg State University, LETI St Petersburg State Electrotechnical University, ITMO University, and Peter the Great St Petersburg Polytechnical University).

Research collaborations with Finland are pursued by several regions of Russia's western borderlands: St Petersburg, the Leningrad and Murmansk regions, and the Republic of Karelia. Finland's population and economic patterns are shifted southward (Helsinki, Turku, and Tampere). This factor and the significant research potential of Helsinki and St Petersburg make close interactions between Estonian research centres, on the one hand, and the Leningrad region and its attractor city (St Petersburg), on the other, a logical step. The geographical proximity of the two strong Baltic centres of research and innovation contributes to their comprehensive integration. Transboundary collaborations with St Petersburg involve the greatest number of researchers from all the regions considered — 2,314 people, which places it far ahead of the second-ranked Leningrad region with 567 people. The city accounts for most joint publications, 2,994, (the Leningrad region ranks second with 914). Twenty-seven Finnish research and education institutions, 5% of all national research centres visible to Scopus, have formed partnerships with their St Petersburg counterparts. Transboundary ties with the Republic of Karelia and the Murmansk region have considerable potential for growth, which is fuelled by the strong interest of Finnish researchers in the findings of their Russian colleagues. The number of Finnish experts citing works authored in the Republic of Karelia is 30% above that of co-authors. As to the Murmansk region, this difference reaches 64.7%. There is a disparity between the number of citations and the number of joint publications: 40.9% in the Republic of Karelia and 61.3% in the Murmansk region. Moreover, the quality of research conducted in collaboration with the Republic of Karelia is 2.61 and that with the Murmansk region 2.39 times the worldwide average. In this respect, the two territories outperform St Petersburg (1.96).

Cross-border cooperation programmes, including those co-financed by the EU (Russia–South-East Finland, Kolarctic, and Karelia), and the Interreg Baltic Sea Region programme ensure the stability of transboundary contacts. Many of these projects support research and knowledge-intensive innovations in environmental protection and ecology. The practical focus of transboundary cooperation is a clear advantage of Russian–Finnish contacts, which gave rise to transboundary clusters of cleantech, energy, and timber companies, thus contributing to the stability of transboundary cooperation. Among the cities involved in active cooperation are Helsinki (the University of Helsinki, the Finnish Meteorologi-

cal Institute, Natural Resource Institute Finland, etc.), Kuopio (the University of Eastern Finland), and the border of Lappeenranta, the administrative centre of South Karelia (Lappeenranta University of Technology).

Norway is a transboundary partner of the Murmansk region. The transboundary research cooperation index for the two areas is 0.273, which is above that for Murmansk–Finland collaborations (0.217). Although the difference in the index values is significant, the disparity between some important measures is even greater. The difference is 1.88-fold when it comes to the number of co-authors from the neighbouring country, 1.80-fold in the case collaborating organisations, 1.89-fold in that of the number of joint publications, and 2.26-fold in that of the number of citations. At the same time, Finland outperforms Norway in some aspects of research interactions with Russian regions: the FWCI (2.39 against 1.68) and the number of networking cities (a threefold difference).

Common research areas are a key factor for cooperation. In this case, these are marine resources, ecology, and Arctic studies. A priority for both countries, projects in these areas receive considerable support. The city of Tromsø, which is located relatively close to Murmansk, is one of the key partners in transboundary cooperation that brings together the University of Tromsø — The Arctic University of Norway and Norwegian Polar University. The latter organises Arctic expeditions and conducts research at the Ny-Ålesund station on the island of Spitsbergen. Some of the expeditions are joint initiatives supported by the Arctic Council, the Nordic Council of Ministers, the Northern Dimension, and other institutions. Other important partners are the Institute of Marine Research (Bergen), Norwegian Institute for Water Research (Oslo), Centre for International Climate and Environmental Research (Oslo), the Geological Survey of Norway, SINTEF (an independent research organisation that conducts contract research and development projects), and Equinor ASA (Norwegian international energy company). These organisations are located at a significant distance from Russian border regions.

Poland is a partner of the Kaliningrad region, Russia's Baltic exclave. This cooperation area has the lowest engagement subindex. Twenty-five organisations are involved in cooperation, yet only three-four researchers from each contribute to cross-border collaborations. Moreover, the proportion of joint studies does not exceed 0.04% of all studies. To a degree, this is explained by the intensive publication activity of Polish research centres collaborating with the Kaliningrad region (over 132.8 thousand publications). In terms of this measure, Polish partners are outperformed only by the Finnish research centres cooperating with St Petersburg (155.3 thousand) and the Republic of Karelia (143.0 thousand). The value of the engagement subindex is rather low (a lower one is observed only in the case of the Smolensk region–Belarus pair). The limited engagement is explained by the low rate of citations of Kaliningrad researchers by Polish colleagues (127,

or 0.05% of all publications). The quality subindex has a rather high level of 0.515, placing the cooperation area seventh among the regions considered. The localisation subindex value is 0.380 (8<sup>th</sup> place).

The most active interactions involve Warmian-Masurian University in Olsztyn, research centres of the Tricity (Gdansk-Sopot-Gdynia, including the Gdansk University of Technology and the University of Gdansk), the Institute of Oceanology and the Institute of Water-Supply Engineering of the Polish Academy of Sciences, Gdynia Maritime University, the National Marine Fisheries Research Institute, and the Polish Naval Academy of the *Heroes of Westerplatte*. Overall, the four cities of the two border voivodeships (Warmian-Masurian and Pomeranian) account for a third (36%) of the collaborating research centres and a half of the publications (46.6%). At the same time, publications of the highest quality were prepared in cooperation with organisations from Krakow (Jagiellonian University and its Medical College), Warsaw (the University of Warsaw, the Jarosław Dąbrowski Military University of Technology), and Wrocław (the University of Wrocław). The average FWCI is 4.45. The fields of cooperation can be divided into two groups: marine studies concentrated in the border voivodeships and medical/biological studies carried out throughout the geographically and institutionally diverse network of cooperation. When considering the measures of the engagement subindex, we established that 67.8% of research centres citing works from their Kaliningrad counterparts did not cooperate with the latter. All these centres were located in remote voivodeships, most of them specialised in maritime studies (the Maritime University of Szczecin) and medicine (the Medical University of Łódź, the Medical University of Warsaw, etc.).

Active interactions are supported by transboundary mobility. An important factor in the latter was the local border traffic regime between Poland and the Kaliningrad region. Contacts in the field of maritime economy are developed by Kaliningrad research centres specialising in the area: the Shirshov Institute of Oceanology of the Russian Academy of Sciences, the Atlantic branch of the Russian Research Institute for Maritime Economy and Oceanography, the Baltic Fish Fleet State Academy, and the Museum of the World Ocean. Research teams of the Institute of Regional Studies at the Immanuel Kant Baltic Federal University (IKBFU) also contribute to the process. Biomedical collaborations are supported by the IKBFU's laboratories, including those located at the Fabrika science park.

Only four Lithuanian research centres have formed partnerships with the Kaliningrad region: Klaipėda University (13 joint publications), Vilnius University (9), Kaunas University of Technology (2), and Vytautas Magnus University (1). The Lithuanian cooperation area has higher engagement (0.047) and commitment (0.073) indices than the Polish one. Firstly, interactions involve at least



eight people per organisation, which is twice the Polish level. Secondly, findings obtained in Lithuanian–Kaliningrad collaborations account for 0.33% of all Lithuanian publications, which is 86.8% above the Polish proportion. Thirdly, the rate of citations of Kaliningrad authors by Lithuanian colleagues is higher than by the Polish ones (0.44% and 0.05%). Alongside the research centres involved in cooperation, citing organisations include the Lithuanian Energy Institute of the Lithuanian Academy of Sciences (Kaunas) and Vilnius academic organisations: Mykolas Romeris University, Vilnius Gediminas Technical University, National Centre of Physical and Technological Sciences. All of these research centres are potential partners. The quality subindex is close to average (0.419 against 0.428). Most of the published works have a FWCI 10% above the worldwide average. The dynamics of transboundary cooperation, however, declined twelvefold in 2015–2018, to one publication. The number of citations of Kaliningrad publications was increasing from 2013, despite a dip in 2017. The average annual increase reached 300% in 2013–2018.

Collaborations with Ukraine are pursued by a considerable number of Russian borderland organisations from the Belgorod, Bryansk, Voronezh, Kursk, and Rostov regions (table 2). At the same time, these regions score among the lowest on the transboundary research cooperation index for 2013–2018 (table 2). The Bryansk region was excluded from the calculation because it had not reached the threshold value of ten joint publications. The levels of commitment and engagement are also rather low (Table 2). The Russian–Ukrainian cross-border cooperation involves only 6% of the Ukrainian research centres visible to Scopus. Most of the Ukrainian organisations collaborate with the Rostov region (26) and the fewest with the Kursk region (11). At the same time, the ties of the Kursk region cover all the university cities of Ukrainian borderlands, whereas the Rostov region collaborates only with 38% of those (three out of eight) and the Belgorod region with 40%. The Voronezh region is the only border area in Russia that does not cooperate with the border research centres of a neighbouring country.

Research cooperation with the Kursk region focuses on materials science and physics. Key Ukrainian partners are the cities of Sumy (Sumy State University) and Kharkiv (Kharkiv Institute of Technology, the Karazin National University of Kharkiv, the Verkin Institute of Low-Temperature Physics, and the Institute of Radio Astronomy of the National Academy of Sciences of Ukraine [NASU]).

The Belgorod region also seeks cooperation with the border cities of Kharkiv (Kharkiv Institute for Physics and Technology, the Karazin National University of Kharkiv, Kharkiv Institute of Technology, Kharkiv National University of Radio Electronics, the Institute of Cryobiology and Cryomedicine of the NASU, Usikov Institute for Radiophysics and Electronics of the

NASU), and Sumy (Sumy State University). Alongside materials science and electrophysics (colloid chemistry, electro-welding, and solid-state physics), the Belgorod region collaborates with Ukrainian research centres in medical and biological fields (cell biology, cryobiology, biochemistry). The number of Belgorod-Ukraine publications is one of the highest in the studied regions (298), second only to St Petersburg and the Leningrad region (collaborations with Finland and Estonia).

The dynamics of research collaborations of the Kursk and Belgorod regions are unstable and often negative. In the Rostov region, the number of joint publication increased in 2013–2018, from eighteen to thirty-four. The area has forged the strongest ties with remote Ukrainian cities — Kyiv (the Frantsevich Institute for Materials Science of the NASU) and Odesa (the Mechnikov National University of Odesa and the Bogatsky Institute of Physics and Chemistry of the NASU). Despite the precarious situation in the region, border cities are integrated into research cooperation. The Litvinenko Institute for Physical-Organic and Coal Chemistry in Donetsk accounts for 14% of all the joint publications. Overall, the border area of Ukraine has four research centres involved in cooperation, including the Institute for Applied Mathematics and mechanics in Sloviansk. Remarkably, top-rated contributions are co-authored by experts from Donetsk (the Litvinenko Institute for Physical-Organic and Coal Chemistry of the NASU, 2.35 FWCI). Physics and engineering are the focus of the collaborations.

Cooperation with Belarus involves many Russian border regions — Pskov, Smolensk, and Bryansk. The number of joint publications in the Pskov region, however, did not exceed ten in 2013–2018. Despite lagging on most subindices, the Belarus-Smolensk region and Belarus-Bryansk region rank in the top five for localisation (0.624 and 0.598 respectively). Particularly, the Smolensk region has formed ties with 11% of the country's research centres and the Bryansk region with 8%. At the same time, there is no direct connection between geographical proximity and research cooperation intensity. The principal co-authors of Smolensk researchers are experts from Gomel State Medical University and various Minsk institutions (City Teaching Hospital No. 9, the First City Teaching Hospital, Belarusian Post-graduate Medical Academy, etc.). Findings from these collaborations have the highest value; the citation rate of the joint publications is five times the worldwide average. The Bryansk region gives priority to collaborations with Minsk institutes of the National Academy of Sciences of Belarus. The proximity factor and transport connectivity make the second-largest city of Belarus Gomel and its research centres (the Francysk Skaryna State University of Gomel, Bely Institute of the Mechanics of Metal-Polymer Systems of the National Academy of Sciences of Belarus) sought-after partners.

This study revealed several patterns in transboundary research cooperation:

— intense research cooperation was observed in regions that boasted an equally high level of research and had considerable commitment to international partnerships;

— complementary competencies and knowledge bases within a common research area was a major factor for forming transboundary ties;

— a strong impetus for developing research cooperation in the borderlands was programmes aimed to support transboundary projects and joint studies;

— the population pattern, economic clustering, and transport connectivity made frequent personal contacts possible and thus contributed to forming research ties;

— a developed transboundary institutional environment, a favourable geopolitical situation, and cultural proximity were important factors in strengthening research cooperation.

### **Acknowledgements**

*This study was supported by the Russian Science Foundation, project No. 19-77-00053 “Knowledge geography: clustering and networking of national competence centers”.*

### **Reference**

1. Marada, M., Chromý, P., Jančák, V., Havlíček, T. 2006, Space polarization and peripheral regions in Czechia. In: Komornicki, T., Czapiewski, K. (eds.). *Regional periphery in Central and Eastern Europe. EUROPA XXI*. Vol. 15. P. 29—34.

2. Vaishar, A., Dvořák, P., Hubačíková, V., Zapletalová, J. 2013, Contemporary development of peripheral parts of the Czech-polish borderland: Case study of the javorník area, *Geographia Polonica*, no. 86 (3), p. 237—253. doi: 10.7163/GPol.2013.21.

3. Vodeb, K. 2012, Competitiveness of frontier regions and tourism destination management, *Managing Global Transitions*, no. 10 (1), p. 51—68.

4. Daugirdas, V., Burneika, D. 2006, Patterns and problems of peripherality in Lithuania—borderland of the EU. In: Komornicki, T., Czapiewski, K. (eds.) *Regional periphery in Central and Eastern Europe. EUROPA XXI*, vol. 15, p. 119—134.

5. Kebza, M. 2018, The development of peripheral areas: The case of West Pomeranian Voivodeship, Poland, *Moravian Geographical Reports*, no. 26 (1), p. 69—81.

6. Bufon, M., Markelj, V. 2010, Regional Policies and Cross—Border Cooperation: New Challenges and New development models in central Europe, *Revista Româna de Geografie Politica*, no. 12 (1), p. 18—28.

7. Tolstoguzov, O.V. 2010, Typology of peripheral regions and features of the boundary periphery of the North-West of Russia // *Regional'naya ekonomika: teoriya i praktika* [Regional Economics: Theory and Practice], no. 47, p. 6—13 (in Russ.).

8. Wackermann, G. 2000, Alsace — changes and perspectives of a European border region, *Geographica Helvetica*, no. 55 (1), p. 45—60. doi: 10.5194/gh-55-45-2000.
9. Baburin, V.L., Zemtsov, S.P. 2013, Geography of innovation processes in Russia, *Vestnik Moskovskogo universiteta. Seriya 5. Geografiya* [Bulletin of Moscow University. Series 5. Geography], no. 5, p. 25—32 (in Russ.).
10. Malyshev, E.A. 2012, Assessment of the potential of innovative self-development of the border territory using the model of cross-border innovative diffusion, *Vestnik Zabaikal'skogo gosudarstvennogo universiteta* [Bulletin of Transbaikal State University], no. 7, p. 111—118 (in Russ.).
11. Khmeleva, G.A., Umerbaeva, S.K. 2015, The mechanism for increasing the efficiency of using the economic potential of the border location of the region, *Vestnik Samarskogo gosudarstvennogo universiteta* [Bulletin of Samara State University], no. 8 (130), p. 106—116 (in Russ.).
12. Suorsa, K. 2009, Regionality, innovation policy and peripheral regions in Finland, Sweden, and Norway, *Fennia*, no. 185, p. 15—29.
13. Tödting, F., Trippel, M. 2005, One size fits all? Towards a differentiated regional innovation policy approach, *Research Policy*, no. 34, p. 1203—1219.
14. Onsager, K., Isaksen, A., Fraas, M., Johnstad, T. 2007, Technology cities in Norway: innovating in glocal networks, *European Planning Studies*, no. 15, p. 549—566.
15. Rodríguez-Pose, A., Fitjar, R.D. 2013, Buzz, Archipelago Economies and the Future of Intermediate and Peripheral Areas in a Spiky World, *European Planning Studies*, no. 21 (3), p. 355—372. doi:10.1080/09654313.2012.716246.
16. Rosič, M., Madziková, A., Klamár, R. et al. 2018, Unemployment in the context of human resources in the eastern part of the Slovak—Polish border region, *Folia Geographica*, no. 15 (48), p. 15—48.
17. Muazir, S., Hsieh, H.-C. 2014, Lagging yet strategic: Tourism and regional development planning in a lagging-outermost-forefront area (borderland) in Indonesia, *Tourism*, no. 62 (4), p. 361—376.
18. Vaessen, P., Keeble, D. 1995, Growth—oriented SMEs in unfavourable regional environments, *Regional Studies*, no. 29, p. 489—450.
19. Usai, S. 2011, The Geography of Inventive Activity in OECD Regions, *Regional Studies*, no.45 (6), p. 711—731. doi:10.1080/00343401003792492.
20. Prokkola, E.K. 2019, Border-regional resilience in EU internal and external border areas in Finland, *European Planning Studies*, no. 27 (8), p. 1587—1606.
21. Pászto, V., Macků, K., Burian, J., Pánek, J., Tuček, P. 2019, Capturing cross—border continuity: The case of the Czech—Polish borderland, *Moravian Geographical Reports*, no. 27 (2), p. 122—138.
22. Klemeshev, A.P., Fedorov, G.M. 2004, *Ot izolirovannogo eksklava — k «koridoru razvitiya»: Al'ternativy rossiiskogo eksklava na Baltike* [From an isolated exclave to the “development corridor”: Alternatives to the Russian exclave in the Baltic], Kalinin-grad, 253 p.

23. Fedorov, G. 2014, The concept of geo-demographic situation and geo-demographic typology of the subjects of the Russian Federation, *Bulletin of Geography*, no. 25 (25), p. 101–114. doi:10.2478/bog-2014-0032.
24. Osmolovskaya, L.G. 2016, Border functions as a factor in the development of border regions, *Vestnik Baltiiskogo federal'nogo universiteta im. I. Kanta. Ser.: Estestvennye i meditsinskie nauki* [Bulletin of the Baltic Federal University. I. Kant. Ser.: Natural and medical sciences], no. 1, p. 45–54 (in Russ.).
25. Runiewicz-Wardyn, M. 2014, The Role of Knowledge Absorption and Innovation Capability in the Technological Change and Economic Growth of EU Regions, *International Journal of Management and Economics*, no. 39 (1), p. 51–69. doi: 10.2478/ijme-2014-0021.
26. Cojanu, V., Gavriș, A., Robu, R. 2016, In search of emerging polities: Thematic agendas of selected european cross—border cooperation structures, *Romanian Journal of European Affairs*, no. 16 (1), p. 57–71.
27. Park, S. 2014, Innovation policy and strategic value for building a cross—border cluster in Denmark and Sweden, *AI and Society*, no. 29 (3). p. 363–375. doi: 10.1007/s00146-013-0460-4.
28. Valdalisio, J.M., Wilson, J.R. 2015, *Strategies for Shaping Territorial Competitiveness*, London, Routledge. doi: 10.4324/9781315772462.
29. Tangkjær C., Jonsson O. Cross—bordering strategies for the øresund region: Different eras and territorial strategies, but unrevealed potential // Strategies for shaping territorial competitiveness. 2015. P. 172–193. doi: 10.4324/9781315772462.
30. Köcker, G.M., Müller, L., Zombori, Z. 2011, *European Clusters Go International — networks and clusters as instruments for the initiation of international business cooperation*, Institute for Innovation and Technology, Berlin.
31. Lundquist, K.L., Tripl, M. 2013, Distance, Proximity and Types of Cross—border Innovation Systems: A Conceptual Analysis, *Regional Studies*, no. 47 (3), p. 450–460.
32. Tripl, M. 2006, Cross—Border Regional Innovation Systems. SRE, *Discussion Papers*, 2006/05, Institut für Regional— und Umweltwirtschaft, WU Vienna University of Economics and Business, Vienna.
33. Doloreux, D., Dionne, S. 2008, Is regional innovation system development possible in peripheral regions? Evidence from the case of La Pocatié`re, *Entrepreneurship & Regional Development*, no. 20, p. 259–283.
34. Chesbrough, H., Vanhaverbeke, W., West, J. 2006, *Open innovation: Researching a new paradigm*, Oxford, Oxford University Press.
35. Doloreux, D., Shearmur, R., Guillaume, R. 2014, Collaboration, Transferable and Non—transferable Knowledge, and Innovation: A Study of a Cool Climate Wine Industry (Canada), *Growth and Change*, no. 46 (1), p.16–37. doi: 10.1111/grow.12090.
36. Bathelt, H., Malmberg, A., Maskell, P. 2004, Clusters and knowledge: Local buzz, global pipelines and the process of knowledge creation, *Progress in Human Geography*, no. 28 (1), p. 31–56.

37. van den Broek, J., Smulders, H. 2013, The evolution of a cross—border regional innovation system: An institutional perspective, *Conference paper RSA European Conference*, Tampere.
38. Frenken, K., Van Oort, F.G., Verburg, T. 2007, Related Variety, Unrelated Variety, and Regional Economic Growth, *Regional Studies*, no. 41 (5), p. 685—97.
39. 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*, no. 16 (3), p. 749—774. doi: 10.1093/jeg/1bv042.
40. Cohen, W., Levinthal, D. 1990, Absorptive capacity: A new perspective on learning and innovation, *Administrative Science Quarterly*, no. 35 (1), p. 128—152.
41. Aksnes, D.W. 2003, Characteristics of highly cited papers, *Research Evaluation*, no. 12 (3), p. 159—170. doi: 10.3152/147154403781776645.
42. Abramo, G., D'Angelo, C.A., Solazzi, M. 2011, The relationship between scientists' research performance and the degree of internationalization of their research, *Scientometrics*, no. 86 (3), p. 629—643. doi: 10.1007/s11192-010-0284-7.
43. Aldieri, L., Guida, G., Kotsemir, M., Vinci C. 2019, P. An investigation of impact of research collaboration on academic performance in Italy, *Quality and Quantity*. doi: 10.1007/s11135-019-00853-1.
44. Torre, A. 2008, On the role played by temporary geographical proximity in knowledge transmission, *Regional Studies*, no. 42 (6), p. 869—889. doi: 10.1080/00343400801922814.
45. Torre, A. 2011, The role of proximity during long-distance collaborative projects. Temporary geographical proximity helps, *Int. J. Foresight and Innovation Policy*, vol. 7, no. 1/2/3, p. 213—230.
46. Bouty, I. 2000, Interpersonal and interaction influences on informal resource exchanges between R&D researchers across organizational boundaries, *Academy of Management Journal*, no. 43 (1). p. 50—65. doi: 10.2307/1556385.
47. Mora-Valentin, E.M., Montoro-Sanchez, A., Guerras-Martin, L.A. 2004, Determining factors in the success of R&D cooperative agreements between firms and research organizations, *Research Policy*, no. 33 (1), p. 17—40. doi: 10.1016/S0048-7333(03)00087-8.
48. Zukauskaitė, E., Trippl, M., Plechero, M. 2017, Institutional Thickness Revisited, *Economic Geography*, no. 93 (4), p. 325—345. doi: 10.1080/00130095.2017.1331703.
49. Curran, W. 2010, In defense of old industrial spaces: manufacturing, creativity and innovation, *International Journal of Urban and Regional Research*, no. 34 (4), p. 871—885. doi: 10.1111/j.1468-2427.2010.00915.x.
50. Maskell, P., Malmberg, A. 1999, Localised learning and industrial competitiveness, *Cambridge Journal of Economics*, no. 23 (2). p. 167—185. doi: 10.1093/cje/23.2.167.
51. Morgan, K. 2004, The exaggerated death of geography: learning, proximity and territorial innovation systems, *Journal of Economic Geography*, no. 4 (1), p. 3—21. doi: 10.1093/jeg/4.1.3.

52. Storper, M., Venables, A.J. 2004, Buzz: face-to-face contact and the urban economy, *Journal of Economic Geography*, no. 4 (4), p. 351—370. doi: 10.1093/jeg/4.4.351.
53. Vissers, G., Dankbaar, B. 2013, Knowledge and proximity, *European Planning Studies*, no. 21 (5), p. 700—721. doi: 10.1080/09654313.2013.734459.
54. Torre, A., Gilly, J.P. 2000, On the analytical dimension of proximity dynamics, *Regional Studies*, no. 34 (2), p. 169—180. doi: 10.1080/00343400050006087.
55. Menzel, M.P. 2008, Dynamic proximities — changing relations by creating and bridging distances. *Papers in Evolutionary Economic Geography (PEEG) 0816*, Utrecht University, Department of Human Geography and Spatial Planning, Group Economic Geography.
56. Kotsemir, M., Kuznetsova, T., Nasybulina, E., Pikalova, A. 2015, Identifying Directions for Russia's Science and Technology Cooperation, *Foresight and STI Governance*, no. 9 (4), p. 54—72. doi: 10.17323/1995-459x.2015.4.54.72.
57. Mikhailov, A.S., Kuznetsova, T.Yu., Peker, I.Yu. 2019, Methods of spatial scientometrics in assessing the heterogeneity of the innovation space of Russia, *Perspektivy nauki i obrazovaniya* [Prospects for Science and Education], no. 5 (41), p. 549—563 (in Russ.).
58. Peker, I. 2019, Application of spatial scientometric methods to the study of individual countries and regions, *Vestnik Baltiiskogo federal'nogo universiteta im. I. Kanta. Seriya: Estestvennye i meditsinskie nauki* [Bulletin of the Baltic Federal University. I. Kant. Series: Natural and Medical Sciences], no. 1, p. 17—27 (in Russ.).
59. Hvalej, D., Mikhaylov, A. 2020, Geography in knowledge flow across borders, *Mendeley Data*, V. 2. doi: 10.17632/n46vg6z2jr.1.
60. Mikhaylov, A.S., Mikhaylova, A.A. 2018, Equivocality in Delineating the Borders of a Cluster: The Baltic's Case, *Balt. Reg.*, vol. 10, no. 2, p. 56—75. doi: 10.5922/2079-8555-2018-2-4.

## **The authors**

**Dr Andrey S. Mikhaylov**, Leading Research Fellow, Immanuel Kant Baltic Federal University, Russia.

E-mail: andrmikhailov@kantiana.ru

ORCID: <https://orcid.org/0000-0002-5155-2628>

**Dr hab., Prof. Jan Andrzej Wendt**, Associate Professor, University of Gdansk, Poland.

E-mail: jan.wendt@ug.edu.pl

ORCID: <https://orcid.org/0000-0003-1712-4926>

**Irina Yu. Peker**, PhD student, Immanuel Kant Baltic Federal University, Russia.

E-mail: [IPeker@kantiana.ru](mailto:IPeker@kantiana.ru)

ORCID: <https://orcid.org/0000-0002-5701-7538>

**Dr Anna A. Mikhaylova**, Senior Research Fellow, Immanuel Kant Baltic Federal University, Russia.

E-mail: [tikhonova.1989@mail.ru](mailto:tikhonova.1989@mail.ru)

ORCID: <https://orcid.org/0000-0002-6807-6074>

---