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CONTENTS

Exclavity

Spatial development

Society

EXCLAVITY

EXCLAVITY OF THE KALININGRAD REGION: EXPERIENCE OF EXPLICATION

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The article explores the concept of exclavity using the Kaliningrad region as an example. The authors analyse the concept of exclavity, identify its key attributes and the degree of their relevance, describe indicators of exclavity as well as factors influencing it. The main attributes of the Kaliningrad region's exclavity are geographical separation and remoteness. The authors distinguish two types of exclavity, absolute (attributive) and relative (functional), identify strategies for overcoming absolute exclavity and offer functional solutions to the 'access problem'. Among these solutions are extraterritorial corridors and transit regimes. Exclaves are viewed as unique border territories where the balance between the barrier and contact functions of the border serves as an indicator of relative exclavity. The authors analyse key factors relevant to absolute exclavity and its functional state: the geopolitical context, the exclave policy of the parent state, the condition of the exclave as a territorial unit, and the identity of its population. The study employs a range of methods and approaches, including logical analysis, case studies, and comparative analysis.

Keywords:
Kaliningrad region, exclavity, geopolitical context, enclavityexclavity, exclave policy, 'exclave syndrome'

Against the backdrop of a global geopolitical crisis and shifting geopolitical dynamics in the Baltic region, the Kaliningrad region's position and role in Russia's pursuit of its national interests are evolving. This evolution is occurring alongside efforts to ensure the security and functionality of the territory as a constituent of Russia. Relevant research into these issues should employ a conceptual model with a significant heuristic component, where exclavity defines the essence of the Kaliningrad region [1—3]. A *sine qua non* here is an explication of the territory's exclavity as a notion and phenomenon alongside its conceptualisation,

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the identification of its fundamental and necessary characteristics (attribute), the definition of its place and significance and the description of principal indicators of exclavity and factors affecting this state[1] [4; 5].

Attributes of the Kaliningrad region's exclavity

Reference books define the word 'exclave' as a portion of a country separated from the main part by another state or states [6, p. 652, 618; 7, p. 571, 540]. In the literature, this term is employed with an analogous meaning[2] [8—10]. A special case arises when such a territory has access to the sea, facilitating maritime communication with the home country. Some authors maintain that if maritime communication is possible, the territory should not be classified as an exclave [13, p. 5]. Yet, it is widely accepted that the decisive factor in determining the status of such areas is their separateness from the home state by land borders and foreign territories [9; 14]. Therefore, such territories enjoying sea access can be designated as 'coastal exclaves'[3] [15]. We tend to agree with this widely-held position, with the added observation that the term 'maritime exclave' also appears to be valid in this case. It is important to note that 'exclave' is a politico-geographical term, and its use immediately introduces a context of physical geography, where further explanations with a focus on political geography and international law may be necessary to clarify the implications of sea access for a specific exclave.[4]

Exclavity is primarily defined as the territorial separateness of a part of a country from its main territory by national borders and territories of one or more state[5] [15, p. 22]. This separateness may be considered an attribute and intrinsic characteristic of the territory designated as an exclave. This characteristic hinders the movement of people and goods between the exclave and the home states[6] [9, p. 18], ultimately challenging the cohesive political, economic, and sociocultural fabric of the nation, to which the exclave belongs. The focus here is not so much

[1] Different interpretations of explication are primarily but non exclusively rooted in Rudolf Carnap's ideas.

[2] It is worth noting that various mathematical approaches are being extensively utilised in identifying and analysing exclaves and enclaves.

[3] The term 'semi-exclave', which has a similar meaning can be considered outdated.

[4] With this qualification, we will use the terms 'coastal exclave' and 'exclave' interchangeably in this text to refer to the Kaliningrad region.

[5] Therefore, it is difficult to agree with the proposition [15, p. 22] that territories separated from the mainland by straits can be classified as coastal exclaves if they share a land border with foreign states, as this border may not separate these territories from the mainland on land. Thus, Northern Ireland is not an exclave of the UK.

[6] In this context, the mainland is often referred to as the 'mother state'. However, this term may not be entirely precise as it could evoke associations with the 'metropole' [9, p. 18].

on technical transport issues as on matters of international politics and law. All this highlights the level of internationalisation of the problems faced by exclaves as integral parts of their states. The issue of movement of people and goods between the exclave and the mainland is termed 'access problem' [8, p. 283—295; 9, p. 184—219; 10].

The separateness and the need to address the 'access problem' constitute the foundation of the conflict potential inherent in exclave territories [16]. On the one hand, the home states of exclaves seek primarily to ensure the unity of the sovereign territory. On the other hand, neighbouring states will be cautious, to say the least, about any attempts to address the 'access problem' involving their territories, concerned about their sovereignty.

Describing the specifics of the Kaliningrad region's separateness from Russia is rather complicated. The region is not just isolated from mainland Russia by the borders and territories of several neighbouring states but is also exposed to a precarious international environment composed of Lithuania, Latvia, Belarus, and Poland, transforming the problem of access from an issue of bilateral relations into a multilateral international problem. The problem is further aggravated by the accession of Poland and Lithuania to the EU and NATO, which has turned the Kaliningrad region into a coastal enclave in relation to these associations, which view it as an object of their coordinated economic and military policy. Moreover, the accession of the two countries to the Schengen zone in 2007 resulted in a common border policy.

All the above suggests that focusing solely on separateness as an attribute of exclavity is insufficient. The characteristic of an exclave's remoteness from the home country, specifically the distance that must be traversed to reach the mainland via transport routes running across foreign territories, is also important [9, p. 212—213]. This type of remoteness, which inevitably acquires an international-political dimension, is fundamentally different from the remoteness observed between the core and periphery of a state. In the case of the Kaliningrad region, the distance to the nearest segment of the Russian state border in the Smolensk region, if travelling by rail or road, is approximately 660 km. For comparison, the width of the Polish Corridor, which separated the coastal exclave of East Prussia from mainland Germany between the two World Wars (1919—1939), did not exceed 200 km and was only 30 km at its narrowest point. The exclave of Cabinda is separated from mainland Angola by a 37 km stretch of the Democratic Republic of Congo. The Azerbaijani exclave of Nakhchivan is separated by a 43 km stretch of Armenian territory. It should be noted that the emergence of new polities can influence characteristics such as remoteness. For example, if we consider Russia and Belarus as constituents of the Union State, the minimum distance from their shared border to the territory of the Kaliningrad exclave would be about 100 km within the so-called Suwałki Gap.

As for the Kaliningrad coastal exclave, which has access to the sea, the distance by sea from Kaliningrad (the port of Baltiysk) to St. Petersburg (the port of Ust-Luga) is 860 km. For comparison, after 2014, Crimea became for a time a coastal exclave of Russia[1] [17, p. 33], separated from Krasnodar Krai by the Kerch Strait, ranging from 4.5 to 15 km in width.[2] Yet it is not sufficient here to merely state the presence of sea access or quantify the distance between the Kaliningrad exclave and mainland Russia's Baltic ports. Equally important is the political and legal mechanism capable of ensuring the stability of maritime traffic across the Baltic Sea, which is classified as a semi-enclosed sea with no open sea areas, as it is entirely covered by the maritime zones of coastal states [18]. The changing geopolitical situation in the Baltic renders this issue extremely pertinent.

Thus, the land-based separateness and remoteness of an exclave are essential attributes for classifying it as a distinct territorial type. These attributes underpin absolute (structural) exclavity, which persists until a reorganisation of borders and territories takes place. Technically, this reorganisation can occur in various ways. For the home state, this could involve purchasing or exchanging the territory that separates the exclave or annexing it. The neighbouring states might take similar actions concerning the exclave territory. Finally, the exclave itself could pursue secession, either to establish an independent state (independentism) or to join another state (irredentism) [19; 20].

In this work, we did not aim to encompass the entire spectrum of hypothetical scenarios related to the Kaliningrad exclave. However, we deem it permissible to make several observations. Firstly, Russia has never made territorial claims against the states it borders via the Kaliningrad region. Moreover, the country has never invoked historical reasons to challenge the preparation and conclusion of the 1997 Treaty on the State Border between Lithuania and Russia [21]. Secondly, the Kaliningrad region has never harboured any threat of separatism in any form. Furthermore, in ethnocultural terms, the region could be described as a Russian 'enclave' in the Polish-Lithuanian catholic environment, as Russians comprise 91.3 % of the region's population, according to the 2020 National Census. Thirdly, since the 1990s, some politicians and 'experts' primarily from Lithuania and Poland have constantly attempted to provoke a discussion about the legitimacy of Russia's control over the region. They admit, nevertheless, that these considerations have inspired various plans for Kaliningrad internationalisa-

[1] Yuri Rozkhkov-Yuryevski believes that Crimea was located in Russian territorial waters and calls it therefore a 'coastal quasi-exclave'. This position seems untenable because, at the time, an essential characteristic of an exclave was evident: being separated on land from mainland Russia by the borders and territory of Ukraine.

[2] Distance matters: the Crimean bridge was built in response.

tion, originating from the West and the neighbouring countries. These scenarios include division, condominium, exterritoriality, decolonisation, greater autonomy and independence[1] [22, p. 36].

On relative/functional exclavity

If a state lacks the capability, desire, or will to address the problem of absolute, or structural, exclavity, it seeks relative, or functional, solutions to sustain the operations of an exclave without altering its borders and status. There are two principal avenues of ensuring functional exclavity.

Firstly, the state can devise ways to solve the problem of 'access', i. e. that of the movement by land of people and cargo between the exclave and the mainland country. Such measures involve organising international transit across a neighbouring state, or states, on terms enshrined in international agreements. Sometimes the question is raised about creating a transport or exterritorial corridor, albeit such steps would solve, to a degree, the problem of absolute exclavity. Obviously, in the case of a coastal exclave, the focus will be on maritime communications.

During the interbellum, Germany's coastal exclave of East Prussia provided a prominent example of attempts to implement all possible solutions for the 'access problem' while maintaining the status of an exclave, as well as addressing the problem of absolute exclavity. When envisaging the 'Polish corridor', the authors of the Treaty of Versailles guaranteed Germany the freedom of transit between East Prussia and the mainland (Article 89).[2] An agreement between Germany, Poland, and the Free City of Danzig, granting free transit between East Prussia and the rest of Germany, was signed in Paris in April 1921. According to Article 9 of this document, an arbitration court was established in Danzig as an institution for resolving disputes between the parties. Over 16 years, only five complaints, all concerning rail transport, were submitted to this court [23]. Rail communication between mainland Germany and its coastal exclave was organised by the German National Railway, which used sealed carriages for this purpose. A special company was also created to ensure maritime communication from Swinemünde (now Świnoujście) to Pillau (now Baltiysk)[3] [14, p. 15; 24, p. 181—230]. However, Germany, seeking to revise the conditions of the Versailles System, raised the issue of creating a 'corridor within the

[1] To support their position, Lithuanian intellectuals appeal to Immanuel Kant, stressing that the German philosopher would have denounced the decisions of the Potsdam Conference [22, p. 34].

[2] Treaty of Versailles, *Moscow*, 1925. URL: https://rusneb.ru/catalog/000199_000009_02000022441/ (accessed 05.10.2023).

[3] For more on the transit conditions, see [24].

corridor', demanding from Poland in 1938 and 1939 the construction of an extraterritorial highway and railway line through the 'Polish Corridor'. This demand exacerbated the international political crisis preceding World War II [25]. At the onset of the war, East Prussia's exclave status was abolished through border adjustments. Ultimately, World War II led to the complete dissolution of Prussia as a sovereign state.

The term 'corridor' as used in diplomacy has historically stirred strong reactions and remains contentious to this day. For instance, in 1996, during a meeting between the presidents of Russia and Belarus, suggesting that Belarus could gain access to the sea via the Grodno-Suwałki-Kaliningrad road and rail route sparked considerable controversy in Poland, perceived as an attempt to discuss an extraterritorial corridor.[1] Another is negotiations between Azerbaijan and Armenia in May 2023, where the term 'Zangezur corridor', designating a transport line between Azerbaijan's exclave of Nakhchivan and the mainland running through Armenian territory, caused disquiet. Armenia's leadership viewed the use of the term as laying territorial claims.[2]

Solutions to the 'access problem' typically refer to the conditions and procedures of transit through neighbouring/surrounding states, i. e. transit regimes, rather than exterritorial corridors, albeit the term 'corridor' is sometimes used to designate such regimes. In modern history, transit regimes have frequently been governed by international multilateral accords, which have, to differing extents, finalised the processes arising from the creation of exclaves. Above, we discussed the Treaty of Versailles and East Prussia. Yet another example is the Four Power Agreement on Berlin, concluded in September 1971 in the wake of détente. The document established transit arrangements between West Germany and West Berlin.[3] In November 2002, Russia and the US issued a joint statement addressing transit between the Kaliningrad region and the rest of the country via Lithuania.

Specific transit conditions were ultimately established in each of the cases considered above,[4] determined by particular historical circumstances. However, it is worth paying special attention to the spirit of these foundational documents. The Treaty of Versailles obliged Poland to provide transit freedom under conditions

[1] Diplomacy of associated series, *Kommersant*, 16.03.1996 ; Around the corridor through Poland. 'Corridor tensions' in the corridors of power, *Kommersant*, 20.03.1996, p. 4.

[2] How the leaders of Armenia and Azerbaijan argued over the word 'corridor' and complained to Putin about each other, *Kommersant*, 26.05.2023.

[3] Four Power Agreement on Berlin, Annex 1. It was emphasised that the Western sectors 'continue not to be a constituent part of the Federal Republic of Germany and not to be governed by it'. For details on the previous period, see: Bespalov, V. A. West Berlin Transit (1945—1971): Cold War Diplomacy, *Moscow*, 2015.

[4] This work did not set out to conduct a comparative analysis of these conditions.

'at least as favourable' as the national Polish regime.[1] The Four Power Agreement specified that transit through the GDR should occur without hindrance, in the simplest and fastest manner, enjoying optimum conditions.[2] The Joint Statement of Russia and the EU explicitly stipulated that the transit regime covered by the document would not infringe upon the sovereign right of Lithuania to exercise necessary control and deny entry into its territory.[3] The latter thesis underpinned the discretionary transit arrangement between the Kaliningrad region and the rest of Russia, anchored not in the principle of international law stipulating unhindered transit between an exclave and the mainland, but in regional EU legislation [26]. The simplified transit document mechanism, which is part of the Russia-EU arrangement, operates as a discretionary visa regime where decisions are made by an anonymous Lithuanian official [26, p. 51]. Moreover, in its own right, the EU merely noted in the Joint Statement 'the Russian proposal for visa-free transit by high speed non-stop train', stating that such a solution 'could only be taken after Lithuania's accession to the EU, based on a thorough evaluation of the political and legal aspects and once the technical obstacles have been overcome'.[4] Lithuania has been an EU member for a considerable time, but the 'thorough evaluation' has not yet occurred.

With the imposition of sanctions and the tightening of the transit regime, amid the growing socio-economic needs of the exclave and the development of modern modes of transport, efforts are being made to mitigate relative exclavity by altering the ratios between different types of transport. For example, by the end of 2001, the volume of passenger traffic between the Kaliningrad region and the rest of the country was estimated at 1.47 million people per year, with 980,000 carried by rail, 240,000 by air, and about 250,000 by road [27, p. 43]. With the complication of passenger transit through Lithuania and the development of fairly accessible air transport, 1.5 million out of two million passengers chose air travel in 2016 [27, p. 44]. COVID and the sanctions have popularised the Kaliningrad region's recreational assets. In 2023, the number of air passengers surpassed four million people,[5] despite aircraft having to adjust their usual routes and slightly extend flight times due to airspace closures by the Baltic States.

[1] Treaty of Versailles, *Moscow*, 1925, p. 43.

[2] Quadrilateral agreement, *Izvestiya,* 04.09.1971.

[3] Joint statement of the Russian Federation and the European Union on transit between the Kaliningrad region and the rest of the territory of the Russian Federation, URL: https://docs.cntd.ru/document/901880999 (accessed 05.10.2023).

[4] Joint statement of the Russian Federation and the European Union on transit between the Kaliningrad region and the rest of the territory of the Russian Federation, Para. 10, URL: https://docs.cntd.ru/document/901880999 (accessed 05.10.2023).

[5] In Kaliningrad, the airport has surpassed the milestone of 4 million passengers per year for the first time, URL: https://tass.ru/obschestvo/19339847 (accessed 05.10.2023).

Given the current restrictions and deteriorating transit conditions for goods through Lithuania, the development of ferry services between the ports of St. Petersburg / the Leningrad region and Kaliningrad has become the sole transport alternative for many types of cargo. The need persists for ongoing monitoring of political, legal, and military-political risks affecting Russian navigation in the Baltic Sea. Following Finland's accession to NATO, Estonian politicians have advocated closing the Gulf of Finland to Russian vessels, while NATO countries practised gulf blockade and Russian territory seizure in the Freezing Winds 23 exercises.[1]

Now we will move on to describe the second way to mitigate relative, or functional, exclavity. Any exclave is a unique border territory, whose administrative boundaries usually coincide with national boundaries: the borders of Kaliningrad as a Russian region coincide with Russia's borders with Poland and Lithuania. In this context, the balance between the barrier and contact functions of the national border comes to the fore alongside the place the border regime has in the policies pursued by Russia, the neighbouring states and their supranational bodies. These considerations govern yet another crucial indicator of exclavity, i. e. the extent of the exclave's openness to global engagement in general and transboundary collaboration specifically [28—30].

It is worth noting that during the transformation of the Kaliningrad region into a Russian exclave, i. e. during the period of 'exclavisation', no specific targets were established for achieving a balance between the border functions. Throughout the 1990s, the balance was clearly skewed towards openness, with various factors affecting the equilibrium. During the initial stage of state-building in the post-Soviet era, the 'transparent' border regime enabled thousands of Kaliningraders to sustain themselves in crisis conditions by engaging in various forms of cross-border trade. The establishment of a free (special) economic zone in the Kaliningrad region spurred the development of business models that were suitable for Russia and provided a boost to numerous small businesses. In 1996, the law on the special economic zone in the Kaliningrad region was adopted, stipulating a free customs zone regime within the region[2] [31]. This regime proved advantageous for the burgeoning Kaliningrad businesses. At the same time, the region was losing its industrial capacity at a faster rate and to a greater extent than the Russian average, leading to the marginalisation of labour resources. By 1995, industrial production in the region had declined to 29 % of the 1990 level (compared to 52 % on average in Russia), while agricultural production had dropped

[1] NATO countries are practicing the blockade of the Gulf of Finland and the seizure of Russian territories at the Freezing Winds 23, 2023, *Military Review*, URL: https://en.topwar.ru/231053-strany-nato-otrabatyvajut-na-uchenijah-freezing-winds-23-blokadu-finskogo-zaliva-i-zahvat-rossijskih-territorij.html (accessed 05.10.2023).

[2] For more on these processes, see [31].

to 59 % (compared to the national average of 72 %). By 1999, industrial production had further decreased to 17 % of the 1990 level, and agricultural production to 47 % [32, p. 8—9]. The metaphor of the 'black hole' was used at the time to refer to the Kaliningrad region in mainland Russia and the EU alike.[1] The Union and the Government of Russia took steps to create mechanisms to regulate the region's earlier 'openness'. Poland's and Lithuania's accession to the EU in 2004 and later to the Schengen area had a profound effect on the border situation. In 2006, legislation regarding the special economic zone in the Kaliningrad region substituted tax incentives for customs exemptions.

Yet another attempt to contribute to the openness of the region was made with the introduction of an agreement on small border traffic between Russia and Poland in 2012 [33], which Poland suspended in 2016. Since the start of the special military operation, the increased barrier function imposed by EU and NATO members Poland and Lithuania has been determining the degree of relative exclavity.

This radically changed the economic conditions initially associated with attempts to weaken exclavity in functional terms.

Conclusion

We believe that this attempt at an explication of the Kaliningrad region's exclavity, including the identification of its absolute and functional aspects, sheds light on the key factors influencing its state and outlines avenues to slip out of the noose of exclavity, at least in functional terms.

The first factor to consider is geopolitical, involving an examination of the geopolitical environment of the Kaliningrad exclave. The most obvious manifestation of the current geopolitical crisis is the 'hybrid war' the West waged on Russia. Although the primary focus is now on the 'Ukrainian front' of this war, the prerequisites for the emergence of a 'Baltic front' are rapidly developing. These conditions involve not only the anti-Russian sanctions and the emergence of a new geo-economic reality for Russia and the Baltic region: the Nord Stream explosion marked the beginning of a movement towards the emergence of a 'Baltic front'. A geopolitically significant act was the accession of Sweden and Finland to NATO, which has not only changed the existing balance of power in the Baltic region but finally destroyed its previous security architecture, an element of which was the neutrality of these states [34]. NATO countries control over 95 % of the Baltic coast, prompting some actors to declare the water body a 'NATO lake'. NATO forward-basing troops are being reinforced in the Baltic States and Poland, the latter state being continuously militarised. Representatives of NATO

[1] Zhukov, V. 1998, Chyornaya dyra na karte Yevropy, Kommersant Vlast', 28 iyulya. [Black Hole on the Map of Europe], *Kommersant Vlast,* July 28.

states, first of all, the Baltics, as mentioned above, are threatening to deny Russia access to the Baltic Sea and block the Danish Straits and the Gulf of Finland for the country. At the same time, Western experts view the Kaliningrad region as the epicentre of confrontation between Russia and NATO, linking its fate to the outcome of military operations in Ukraine.[1] In recent years, expert attention has been focused on the Suwałki Gap, dubbed the 'most dangerous place on earth',[2] which is considered a pivotal area for the West in terms of defending the Baltic States.[3] This is not a security dilemma but a point of potential escalation where the threat of the annexation of the exclave will become real rather than verbal. Yet, the position of Russia's outpost in the Baltic region is preferable to that of a besieged fortress. Therefore, strengthening military presence in the Kaliningrad exclave is a vital task.

The second critical factor is Russia's exclave policy. In previous years, it sought to mitigate the functional exclavity of the Kaliningrad region by optimising transit arrangements and increasing the territory's openness, with the mechanism of the special economic zone playing a key role. At the same time, timely steps were taken to strengthen the exclave's energy and food security. The current situation, however, calls for a more radical renewal of the federal policy towards the exclave, with the possibility of partial blockade taken into account. This renewal should include not only the diversification of transport flows but also a revision of priorities and specialisations.

The region's air communication plans should be yoked together with the development of recreational assets, which will ultimately endow Kaliningrad with a new kind of openness, sustained by the influx of tourists from the mainland. The sea ferry route should be part in providing the region's functionality and security. A special programme needs to be developed to enhance the transport connectivity of Kaliningrad with the rest of the country.

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[1] Hamilton, D.S., Pita, A. 2022, Why is Kaliningrad at the centre of a new Russia-NATO faceoff?, *Brookings*, URL: https://www.brookings.edu/articles/why-is-kaliningrad-at-the-center-of-a-new-russia-nato-faceoff/ (accessed 05.06.2023) ; Hedlund, S. 2023, "Lake NATO": What's next for Russia's Kaliningrad?, *The National news*, URL: https://www.thenationalnews.com/weekend/2023/07/28/russia-nato-sweden-kaliningrad-ukraine-baltic/ (accessed 05.06.2023).

[2] Karnitschnig, M. 2022, The Most Dangerous Place on Earth, *Politico*, URL: https://www.politico.eu/article/suwalki-gap-russia-war-nato-lithuania-poland-border/ (accessed 05.06.2023).

[3] Kallberg, J. 2024, Code Red: How Russsia Conquers the Boltics, *CEPA*, URL: https://cepa.org/article/code-red-how-russia-conquers-the-baltics/ (accessed 05.06.2023) ; Deni, J.R. 2022, NATO Must Prepare to Defend Its Weakest Point-the Suwalki Corridor, *Foreign Policy*, URL: https://foreignpolicy.com/2022/03/03/nato-must-prepare-to-defend-its-weakest-point-the-suwalki-corridor/ (accessed 05.06.2023) ; Veebel, V., Sliwa, Z. 2019, Kaliningrad and Russa's Baltic Ambitions, *Journal of International Studies*, vol. 12 (3), p. 109—121, https://doi.org/10.14254/2071-8330.2019/12-3/9

In addition to leveraging recreational resources, a second priority for the region's socio-economic development could be its transformation into a testing ground for innovative technical, economic, and social solutions, such as electric transport and recreational medicine. A federal law on Russia's exclave territory should provide the institutional framework for an updated federal exclave policy.[1] The document should include mechanisms to support not only the region's businesses but also its population, which has found itself in entirely unique circumstances.

Finally, it is worth paying attention to the state of regional society and its identity. In the nascent phase of the Russian Federation, Kaliningrad exhibited indicators of all-Russian identity development that aligned with the national mean. However, the Kaliningrad version of all-Russian identity was shaped to a degree by a relatively long period of openness towards Europe. The rapid 'closing' of the exclave by the West may lead to cognitive dissonance and psychological discomfort caused by the clash between established perceptions of life in the region and new realities. This could give rise to an 'exclave syndrome', characterised by the feeling of isolation and detachment under harsher geopolitical and geoeconomic conditions of closure and conflict. The best remedy here may be the successful implementation of two federal priorities: the development of the recreational industry and the region's transformation into a socioeconomic testing ground. Moreover, fully leveraging the emerging infrastructure to showcase examples of Russian high culture, alongside developing preferential air links for Kaliningrad residents with the mainland, could prove beneficial.

The explication of the Kaliningrad region's exclavity offers insight into its specific characteristics as an exclave territory, its history, and ongoing processes, while also helping to anticipate future scenarios.

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References

1. Klemeshev, A.P. 2005, Exclave as a factor of Kaliningrad region development, *Vestnik of IKBFU. Series: Humanities and Social Sciences*, vol. 3, p. 34—41. EDN: HVRIDN

2. Klemeshev, A.P. 2009, Russian exclave on the baltic: evolution of exclavity and ways to overcome it, *Baltic Region*, vol. 2 (2), p. 86—97. EDN: KYPVIB

[1] This issue was discussed in the previous years.

3. Sebentsov, A. B., Zotova, M. V. 2018, The Kaliningrad region: challenges of the exclave position and ways to offset them, *Baltic Region*, vol. 10, № 1, p. 89—106, https://doi.org/10.5922/2074-9848-2018-1-6

4. Brun, G. 2016, Explication as a method of conceptual Rre-engineering, *Erkenntnis*, № 81, p. 1211—1241, https://doi.org/10.1007/s10670-015-9791-5

5. Boniolo, G. 2003, Kant's Explication and Carnap's Explication, *International Philosophical Quarterly*, vol. 43, № 3, p. 289—298, https://doi.org/10.5840/ipq200343335

6. *Encarta World English Dictionary*. 1999, New York, St. Martin's Press, p. 652, 618.

7. Collins English Dictionary. 1996, HarperCollins Publishers, p. 571, 540.

8. Robinson, G. W. S. 1959, Exclaves, *Annals of the Assotiation of American Geographers*, vol. 49, № 3, p. 283—295, https://doi.org/10.1111/j.1467-8306.1959.tb01614.x

9. Vinokurov, E. Y. 2007, *A Theory of Enclaves*, Kaliningrad, 342 p.

10. Nies, S. 2015, Enclaves in International Relations, *LAP Lambert Academic Publishing*, 364 p.

11. Suzuki, S., Inohara, T. 2015, Mathematical definitions of enclave and exclave, and applications, *Applied Mathematics and Computation*, vol. 268, p. 728—742, https://doi.org/10.1016/j.amc.2015.06.114

12. Wang, X. 2023, Identification of enclaves and exclaves by computation based on point-set topology, *International Journal of Geographical Information Science*, № 37 (2), p. 307—338, https://doi.org/10.1080/13658816.2022.2120995

13. Catudal, H. M. 1979, The Exclave Problem of Western Europe, *Tuscaloosa: University of Alabama Press*, p. 126.

14. Lunden, T. 2012, 'Exclaves — Geographical and Historical Perspectives' in Jańczak, J., Osiewicz, P. [eds.], *European exclaves in the process of de-bordering and re-bordering*, Berlin: Logos Verlag Berlin, p. 11—19.

15. Zverev, Yu. M. 2018, Coastal exclaves among enclosed territories of the world, *Vestnik of Immanuel Kant Baltic Federal University. Series: Natural and Medical Sciences*, № 4, p. 18—32. EDN: YVBBVZ

16. Klemeshev, A. P. 2005, *Russian exclave: overcoming conflictogenicity*, Saint Petersburg State University Publishing house, 263 p.

17. Rozhkov-Yuryevsky, Yu. D. 2016, Kaliningrad and crimea as russian exclaves: similarities, differences, and interconnections, *Vestnik of Immanuel Kant Baltic Federal University. Series: Natural and Medical Sciences*, № 3, p. 28—44. EDN: XBOEPR

18. Gudev, P. A. 2023, Freedom of Navigation in the Baltic (Risks and Challenges for the Russian Federation), *Sovremennaya Evropa*, № 7, p. 98—110, https://doi.org/10.31857/S0201708323070082

19. Popov, F. A. 2011, Secessionism as a security threat, *Eastern Analytics*, № 2, p. 84—93. EDN: PAVSLT

20. Nurullin, R. M. 2010, On the concept of secession in political science, *Uchenye Zapiski Kazanskogo Universiteta Seriya Gumanitarnye Nauk*i, vol. 152, 1, p. 212—221. EDN: LDFTID

21. Plotnikov, F. Yu. 2024, *The Baltic frontier. History of the conclusion of the Russian-Lithuanian border treaty*, URSS, 112 c.

22. Jokubaitis, A., Lopata, R. 2010, Geopolitical transformation of the Kaliningrad oblast of the Russian Federation, *Baltic Region*, № 2 (4), p. 24—38, https://doi.org/10.5922/2074-9848-2010-2-3

23. Timirev, I. A. 2006, Danzig international arbitral court and the problem of east-prussian transit, *Vestnik of Immanuel Kant Baltic Federal University*, № 12, p. 51—55. EDN: HZKWKZ

24. Morrow, I. F. D. 1936, *The Peace Settlement in the German Polish Borderlands: A Study of Conditions To-day in the Pre-war Prussian Provinces of East and West Prussia*, Oxford University Press, H. Milford, p. 558.

25. Narinsky, M. M. 2009, The international political crisis on the eve of the Second World War, *MGIMO Review of International Relations,* № S4, p. 23—47. EDN: KUYLXL

26. Kiseleva, E. 2005, Kaliningrad Transit: Why to facilitate?, *Lund University*.

27. Gumenyuk, I. 2023, Adaptation of mechanisms for ensuring transport security of the Kaliningrad region in the new geopolitical and geo-economic realities, *Pskov Journal of Regional Studies*, vol. 19, № 2, p. 41—51, https://doi.org/10.37490/S221979310025345-2

28. Osmolovskaya, L. 2016, Border functions as a factor of development of border regionsand the formation of cross-border regions, *Vestnik of Immanuel Kant Baltic Federal University. Series: Natural and Medical Sciences*, № 1, p. 45—54. EDN: VXCYJF

29. Gumenyuk, L. 2022, Functional-time variability of the boundary (case of Kaliningrad oblast borders), *Regional Research*, № 3 (77), p. 90—99, https://doi.org/10.5922/1994-5280-2022-3-8

30. Kolosov, V. A., Sebentsov, A. B. 2023, The border as a barrier and an incentive for the structural economic transformation of the Kaliningrad exclave, *Baltic Region*, vol. 15, № 4, p. 104—123, https://doi.org/10.5922/2079-8555-2023-4-6

31. Sebentsov, A., Zotova, M. 2013, Geography and economy of the Kaliningrad region: limitations and prospects of development, *Baltic Region*, № 4 (18), p. 81—94, https://doi.org/10.5922/2079-8555-2013-4-8

32. Fedorov, G. M. 2019, Three development strategies of the Kaliningrad region (1991—2018), *Vestnik of Immanuel Kant Baltic Federal University. Series: Natural and Medical Sciences*, № 3, p. 5—19. EDN: HXPYPA

33. Gumenyuk, I., Kuznetsova, T., Osmolovskaya, L. 2016, Local border traffic as an efficient tool for developing cross-border cooperation, *Baltic Region*, vol. 8, № 1, p. 67—82, https://doi.org/10.5922/2074-9848-2016-1-6

34. Smirnov, P. Ye. 2023, The Accession of Finland and Sweden to NATO: Geopolitical Implications for Russia's Position in the Baltic Sea Region, *Baltic Region*, vol. 15, № 4, p. 42—61, https://doi.org/10.5922/2079-8555-2023-4-3

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SPATIAL DEVELOPMENT

RUSSIA'S SPATIAL DEVELOPMENT AND THE EMERGING GREATER EURASIA: FACTORS, TRAJECTORIES AND PRIORITIES

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Contemporary Russia's spatial development is markedly affected by profound geoeconomic and geopolitical shifts, progressively more visible in terms of magnitude and repercussions. For Russia, the positive impact of these changes has become increasingly linked to the emergence of the Greater Eurasia macro-structure. This article aims to develop a contemporary conceptual approach to Greater Eurasia as a socio-geographical mega-structure given Russia's opposition to the collective West. Additionally, it seeks to identify, using this approach, the strategic interests, opportunities and limitations of Russia's spatial dynamics on the path towards Eurasian continentalism, which promotes transboundary cooperation and mutually supportive co-development of Eurasian states. The focus of this contribution is on the most crucial contemporary trends and principal contradictions in the transformation of the Russian space. The study provides a picture of the framework of 'greater' Eurasian integration, emphasising its connection to intensifying interregional and inter-municipal interactions. A rationale is outlined for shifting the country's economic activity towards the east and north, with priorities identified given the inertia of spatial processes and the growing significance of Siberia in the Russian space. The potential and efficiency of prolonging the 'Moscow-centric' arrangement of the Russian space are assessed from the perspective of ensuring the multidirectional development of the latter. Special attention is paid to the 'municipalisation' of approaches to the strategic planning of Russia's spatial development in the context of Eurasian continental integration.

Keywords:
spatial development, integration processes, municipalities, Greater Eurasia, Eurasian continentalism, Russia, Siberia

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Introduction and problem setting. The radical exacerbation of the geopolitical situation in 2022, when the world was believed [1] to be on the brink of a new world war, created serious threats to Russia's national security. The confrontation has reshaped the country's priorities in the economy, transport, logistics, foreign trade, spatial development and other spheres. Sanction pressures from the 'collective West' have resulted in the weakening or complete severance of ties with countries deemed unfriendly. Notably, Western countries comprised 65 % of Russia's foreign trade in 2019 [2]. The transit of Russian goods through the territories of EU and NATO member states has become more complex. Maritime transport options in the western direction have become less viable as well due to potential vulnerabilities at exits from the Baltic and Black Seas. Access of Russian company ships to European ports is being denied along with the entry of foreign ships into Russian ports, leading to the cessation of cargo insurance and the halt of services for Russian vessels. These restrictions result in either the disruption or lengthening of logistical chains, growing transportation and transaction costs, reduced efficiency of export-import operations and consequently, risks for the country's economy and its territories.

There are two avenues to mitigate the emerging problems and threats — the developments extensively explored and systematised in the literature, including by Russian social geographers [3—5]. The first is the formation of a powerful autonomous Russian economy. This would require efforts to evolve national raw material processing along with high-tech production, promote import substitution and obtain diversified end products. The second involves refining and strengthening integration with 'friendly' Eurasian states, aiming to reduce dependence on the market of the 'collective West'. This approach aligns with the contemporary trend of economic regionalisation, which is well within the logic of the prevailing cycle of disintegration [6]. These avenues complement each other and should be pursued simultaneously, along with the overall strengthening of Russia's global position. Fortifying the nation's standing would require Russia's full and productive participation in establishing an alternative to the current dominant global 'centre of power'. This way, the global 'poles' will be balanced by creating a union, or bloc, of several 'non-Western' Eurasian countries. Since late 2015-early 2016, this somewhat amorphous, fragmented, asymmetric and externally vague structure has been conceptualised and identified in Russian scientific discourse as Greater Eurasia [7—11].

The relevance of this topic is growing along with scholarly interest: as of December 2023, the RINC database contains 2,459 articles focusing on the issue. However, further research is required to explore the social geographical aspects of the formation of Greater Eurasia and the conditions and consequences of Russia's development within this context. Very few studies have delved into the transformations of Eurasian continental integration, a topic gaining impor-

tance as China, which has become Russia's primary trade partner amid the special military operation, solidifies its economic position. There is an urgent need to evaluate the effect of such integration on the priorities and strategies of Russia's spatial development. Moreover, the interests of Russian regions and their constituent municipalities have not been clearly defined. It is also necessary to investigate the possibilities and limitations of forging complementing economic ties and running major integration projects within the framework of the emerging macro-regional bloc. The key aspects of creating Greater Eurasia need to be further explored, including its composition, boundaries, prerequisites, barriers and territorial and other bonds holding together such large and diverse countries. There is no thorough understanding of the limits, depth and formats of their economic and political integration. Nor is it clear what global transport infrastructure projects should be given priority to open up new opportunities for the parties involved and specific territories. In light of the above considerations, this article aims, on the one hand, to provide an economic-geographical rationale for Russia's Eurasian continentalism strategy, which, as we believe, is a major trajectory and potential catalyst for the country's development. On the other, it seeks to determine the interests, opportunities and limitations of Russia's spatial development within the framework of Greater Eurasia.

It is important to highlight that we will approach the formation of Greater Eurasia through the lens of Russia's spatial development. Thus, along with analysing the phenomenon of Greater Eurasia and the country's position within it, we will examine its influence on the Russian space: the formation of a multidirectional spatial development paradigm, a recent surge of interest in understanding the role of Moscow, its environs and eastern regions in the country's socio-economic development, and the need to pay closer attention to municipalities.

The phenomenon of Greater Eurasia and its impact on the spatial dynamics of Russia: a conceptual approach. When exploring and conceptualising Greater Eurasia as a factor in Russia's spatial development, it is important to bear in mind that this unique phenomenon embraces a multitude of integration structures, processes, and projects, all unfolding simultaneously and concertedly within the main massif of Eurasia. This circumstance leads to Eurasian polycentrism, bringing it into the spotlight and complicating the issue of defining the boundaries of Greater Eurasia. Multiple conflicting demarcations (see [7; 8; 12]) arise as a result. Delimitation of Greater Eurasia can only partly and in the most general way rely on the boundaries of institutionalised associations involved in the Greater Eurasian partnership of states or groups of states. Nor would it be advisable to equate the geographical extent of Greater Eurasia with the combined territory of these countries.

The cohesion of Greater Eurasia, albeit real, may sometimes appear theoretical, notional and elusive. It is shaped not so much by the actual socio-economic proximity and integrity of individual states as by the territorial configuration and geographical circumstances. Although most countries comprising Greater Eurasia remain geopolitically remote from the 'collective west', not all of them are its outright opponents. Moreover, competition among Eurasian states, at times escalating to confrontation, is also present. Neighbourhood is a significant but not decisive factor in in the geoeconomy of many de facto actors in Greater Eurasia. For all 12 non-European landlocked states of Eurasia, which account for 6.5 million km^2 and 160 million population, using the neighbourhood factor to its full capacity is tantamount to gaining entry into the global market, i. e. it is a question of survival.

Both as an idea and an actual economic-geographical construct, Greater Eurasia initially pursued dynamic and sustainable growth characteristics of almost all Asian states due to their demographic landscapes. Another principal growth factor was burgeoning logistics, which has enabled the creation of production and distribution chains connecting Europe and China, as well as other territories. The nascent disintegrative world order trends and geopolitical considerations have made the Greater Eurasia project even more important for Russia (particularly amid the special military operation), adding momentum to the ever more visible shift towards Asia.

From Russia's perspective, Greater Eurasia is significantly Sinocentric in economic terms, which corresponds to reality as the Belt and Road initiative serves as the main driver of Eurasian integration. Typical of this vision is the perception of China as a catalyst for revitalising the Russian economy and accelerating extensive integration within the EAEU [13, p. 65]). In demographic and geopolitical terms, Greater Eurasia is asymmetrically polycentric. It is worth noting that the narrative of a broad Eurasian partnership is largely of Russian origin, circulating and looming large in the country and among its closest allies. This narrative derives from the renaissance of classical Eurasianism, as seen in Pyotr Savitsky's concept of 'landlocked neighbourhoods', and a reincarnated notion of Greater Europe — a single space between Lisbon and Vladivostok [14] — adapted to the post-Crimean situation. Utilising the latter idea not only provides an additional conceptual framework for Russia's turn to the East, whose major precepts were declared as early as the second half of the 2000s [10] but also raises the profile of 'minor' Eurasian integration (Leonid Vardomsky, for example, notes that Eurasian cooperation in the EAEU format lacks 'a discernible trend towards an increase in trade and economic cohesion' [15, p. 113]). Yet, as Leonid Bezrukov writes [7], the economic-geographical purpose of Greater Eurasia is to achieve sustainable continental Eurasian integration by activating international economic ties and creating transport corridors. In other words

(see [16]), it seeks to establish new organisational forms for people, infrastructure and economic activities on vast, heterogeneous and fragmented expanses of Eurasia in response to the drift of the geoeconomic and geopolitical potential towards the east and west. These organisational forms encompass transport corridors, industrial hubs, cross-border cooperation zones, transboundary regions and areas of cross-cultural interactions. Taken together, they can be defined as a dispersed mega-structure comprising the support framework of Greater Eurasian integration, which, in turn, is a product of a combination of multi-aspect multidirectional Eurasian partnerships and alliances. Under the influence of demographic and economic factors, these organisational forms have taken on a transcontinental Asian-European nature, gravitating towards the landlocked areas of Eurasia. These circumstances provide a basis for postulating Eurasian continentalism as a distinct worldview, a unique geostrategy and an integrative region-building socio-geographical process, which significantly impacts Russia by influencing its regions and municipalities.

It is crucial to bear in mind that Greater Eurasia is not so much a 'structure of structure' as a spatial structure superimposed on existent spatial formation. Therefore, the relationship between the Russian space and the area of Greater Eurasian integration should not be viewed as merely that between a part and the whole. It should also be noted that continentalism is primarily interpreted as a set of ideas, approaches, and practices of a state's inland expansion [17; 18], often contrasted with similar endeavours by 'maritime' powers [19; 20]. Although Eurasian continentalism was previously associated exclusively with Russia's interests [21—23], in recent years, China has been increasingly named as the beneficiary of this process [24; 25].

In post-Soviet Eurasia, where various multiscale multidirectional spatial expansions coexist with evolving practices of partnership and cooperation, it is reasonable to distinguish between particular continentalisms (Chinese, European, Russian, Turkish-Turkic, Iranian, etc.) and a unified Eurasian continentalism. The latter carries a meaning that is markedly different from earlier interpretations, one that considers the multi-actor and polycentric nature of Eurasia, focusing on low-conflict, mutually beneficial, and mutually supportive co-development of Eurasian states.

This type of continentalism seems to underpin the formation of the spatial structure of Greater Eurasia, which fulfils three functions in relation to the Russian space. Firstly, it provides a new partly institutionalised external framework and a preferable exogenous environment. Secondly, it represents a prolonged structure shift. Thirdly, Greater Eurasia serves as the 'friendly other' encompassing the Russian territories that are explicitly, latently or potentially involved

in Greater Eurasian integration. This integration is seen as both the impetus for and the outcome of transformations. Driven by external sub-global factors, these changes are linked with additional opportunities, new characteristics, and risks.

Although the trends and innovations associated with Eurasian integration have become visible and tangible, they are not sufficient to overcome the inertia of the Russian space. Nor are they capable of effectively restructuring the country's core-periphery landscape, its natural, economic and settlement zoning or national features of regionalisation. Their potential impact and multi-aspect spatial socio-economic, geocultural and geopolitical consequences largely correlate with Russia's position and role in Eurasia in the processes of shaping its renewed 'greater' boundaries.

The place and role of Russia in the Emerging Greater Eurasia: a socio-geographical aspect. Russian geographers are becoming increasingly aware of the outlines of a new reality, which they will need to conceptualise and explore. A principal aspect of this new reality is the growing duality, instability and ambiguity of Russia's standing in the emerging Greater Eurasia. On the one hand, Russia is potentially the largest member of this integration project, occupying 32 % of Eurasia's territory and holding an advantageous position due to the vastness and configuration of its borders shared with 16 countries, which account collectively for nearly 29 % of Eurasia's population. These circumstances objectively determine not only Russia's trans-Eurasian transport and transit opportunities but also its geopolitical significance as the core of Greater Eurasian integration [8]. On the other hand, for modern Russia, a Greater Eurasian unity highlights the loss of the country's exclusive geostrategic standing once enjoyed by the USSR against the background of the rising influence of other 'centres of power' in the post-Soviet space. Yet another concern is the prospect of forfeiting Russia's core position due to a combination of demographic and economic trends, as well as environmental and climatic characteristics.

The average population density across Eurasia is 12 times that in Russia. The country's demographic contribution to Eursia (and 'demography is destiny'[1]) has been constantly shrinking, amounting to 4.6 % in 1970, 3.7 % in 1990 and 2.7 % in 2022.[2] Furthermore, the country's economic positions have been extremely unstable throughout the entire post-Soviet period (Table 1).

[1] Zakaria, F. 2024, The Self-Doubting Superpower. America Shouldn't Give Up on the World It Made, *Foreign Affairs*, URL: https://www.foreignaffairs.com/united-states/self-doubting-superpower-america-fareed-zakaria?check_logged_in=1&utm_medium=promo_email&utm_source=lo_flows&utm_campaign=registered_user_welcome&utm_term=email_1&utm_content=20231227 (accessed 09.01.2024).

[2] Calculated by the authors based on data from *World Population by Country 2024*, database.earth, URL: https://database.earth/population/by-country/ (accessed 29.12.2023).

Table 1

The volume and development level of the Russian economy as compared to the performance of some Eurasian states (Russia = 100)

State	GDP at official exchange rates				GDP per capita (PPP)			
	1998	2008	2019	2022	1998	2008	2019	2022
China	378	277	843	802	45	38	55	59
Japan	1512	307	302	189	467	175	141	126
Germany	826	226	230	182	463	187	190	175
India	155	72	167	153	34	18	23	23
UK	610	176	168	138	433	182	164	151
France	555	176	161	124	427	174	168	153
Italy	469	145	119	91	458	176	152	145
Republic of Korea	141	63	98	75	247	149	144	139
Indonesia	35	31	66	59	80	38	41	40
Saudi Arabia	54	31	50	49	697	243	163	163
Turkey	102	46	45	40	164	80	93	103
Iran	41	25	17	18	183	86	49	50
Kazakhstan	8	8	11	10	119	89	91	85
Ukraine	15	11	9	7	70	47	44	35

Prepared based on World Bank data (URL: https://databank.worldbank.org).

Gradually overcoming the wide post-Soviet disparity between its economy and those of now unfriendly states, as well as Japan, Russia forges alliances within Greater Eurasia with influential states such as China and India, which have experienced faster economic and demographic growth in recent years. This objectively aggravates Russia's positions, limiting its potential influence on other post-Soviet states, including those in the South Caucasus and Central Asia. At the same time, vast Russian territories are turning into double semi-periphery/periphery, with borderlands being the most affected areas.

In these conditions, Russia should develop and reconstruct its own space, aligning with the logic and interests of Eurasian continentalism. To this end, it is essential to initiate and bolster transboundary region-building with the participation of friendly states. Moreover, Russia should uphold its centuries-old territorial model, functional connectivity, hierarchy of urban centres and patterns of interregional interactions. Thus, the country would ensure internal cohesion while preserving a socio-geographic basis for sovereign, geopolitically flexible and multidirectional spatial development.

Unlike China, Russia cannot be victorious in the confrontation with the West if it plays by the rules established by the latter. Aware of this circumstance, the West, particularly the US, tend to radically change these rules to serve its inter-

ests. In this context, Russia is forced to act as Europe's, and the world's, most conspicuous revisionists,[1] challenging the order that was established with total disregard for its interest and experiencing growing pressure from all directions.

The beginning of the special military operation marked a transition to an entirely new period in the country's development, albeit prerequisites for this change had emerged over the previous years. It is the hour of triumph for manufacturing sectors — a fact that Russia's geopolitical opponents could not but acknowledge.[2] Hi-tech industries are flourishing in the regions that have traditionally been hubs of such activities and expanding into new territories.[3] These changes are not only indicative of deglobalisation and localisation of the value chain within the country and friendly nations but also betoken demetropolitanisation, i. e. the transfer of points of economic growth from globalised cities and their agglomerations to revitalised industrial centres.

While the historic feat of the USSR, which was an unfree country, was giving freedom of choice to non-Western nations, as Sergey Karaganov has repeatedly emphasised, China's considerable accomplishment was dispelling the illusion about the absence of alternatives to the liberal development model, which weds a market economy with the Western interpretation of pluralistic democracy. Now, Russia too can reproduce the Soviet achievement by demonstrating to Eurasia and the world an alternative spatial organisation model rooted in reindustrialisation and demetropolitanisation.

One can, and in effect should, await positive changes in Russia's education and healthcare. Ranking 51st on the Human Development Index, Russia outstrips by far almost all of its friendly Eurasian partners.[4] Yet, there is an urgent need to expand the country's potential in research and technology. In 2022, Russia ranked 47th in the Global Innovation Index, while China, Turkey and India scored

[1] Shuper, V. 2022, Rossiya kak kolybel' revizionizma [Russia as the cradle of revisionism], 25.05.2022, *Valdai international discussion club*, URL: https://ru.valdaiclub.com/a/highlights/rossiya-kak-kolybel-revizionizma/ (accessed 05.01.2024).

[2] Prokopenko, A. 2024, Putin's Unsustainable Spending Spree. How the War in Ukraine Will Overheat the Russian Economy, 08.01.2024, *Foreign affairs*, URL: https://www.foreignaffairs.com/russian-federation/putins-unsustainable-spending-spree?utm_medium=newsletters&utm_source=fatoday&utm_campaign=Putin's%20Unsustainable%20Spending%20Spree&utm_content=20240108&utm_term=FA%20Today%20-%20112017#author-info (accessed 08.01.2024).

[3] Suntsova, Yu. 2023, Konets fil'mov. V Izhevskye zakryvayut tretiy TTs [The end of movies. A third shopping center is closing in Izhevsk] 15.09.2023, *Novye Izvestiya*, URL: https://newizv.ru/news/2023-09-15/konets-filmov-v-izhevske-tretiy-tts-zakryvayut-pod-proizvodstvo-bespilotnikov-419358?ysclid=lo1rl3a1ta758528015 (accessed 23.12.2023).

[4] Human Development Index (HDI) by Country 2024, *World Population Review*, URL: https://worldpopulationreview.com/country-rankings/hdi-by-country (accessed 24.12.2023).

higher: 11th, 37th and 40th, respectively. Buttressed by sustainable socio-economic development, success along these lines can counterbalance the country's peripheralisation, rendering Russia one of the key members in a genuinely, rather than declaratively, polycentric Greater Eurasia.

Multidirectionality of Russia's spatial development: problems and trajectories in the context of the emerging greater Eurasia. A largely coastal country with vast borderlands, Russia is exposed to multiple neighbourhoods (as described by Andrey Treivish [26]). Indeed, 51 regions, accounting for 77.5 % of the country's territory, have land or sea borders with other countries. Moreover, its spatial development is increasingly characterised by multidirectionality, which has become ever more pronounced amid the formation of Greater Eurasia.

Much in line with the concept of Greater Eurasian integration, the eastern direction has recently been considered principal, as reflected in Russia's Spatial Development Strategy 2025.[1] Sharing this vision, we nevertheless emphasise the need for a socio-geographical specification of the country's turn to the East. This elaboration would, firstly, help overcome the thinking trap of oversimplified and superficial perception of the issues that do not consider the particularities of the Russian space. Secondly, it would emphasise that the turn to the east does not consist solely in fostering the advanced development of Siberia and the Russian Far East, which, as frequently highlighted in the literature [27—30], is experiencing depopulation, and the relevant cross-border, transboundary and export-related aspects, but it also involves the prolongation and reformatting of Russia's post-Soviet maritime focus, including the efforts to evolve the Northern Sea Route [3]. Eurasian continentalism should be placed within this broader context as an ideologeme and the practice of forming, sustaining and stimulating inland and marine-inland integrative transnational and transboundary structures and processes.

If Russia is considered a leading and sovereign actor in Eurasian integration rather than a semi-periphery/periphery eclipsed by the rapidly developing exogenous cores, the movement of population and the economy towards the south and east, particularly towards the border and coastal areas, seems to be the most logical and geostrategically advantageous response for the Russian space to the Greater Eurasia factor. This process should take place alongside the strengthening of Russia's historical socio-economic core — the Moscow region and its adjacent regions in conjunction with the Saint Petersburg agglomeration. In re-

[1] On the approval of the Strategy for the Spatial Development of the Russian Federation 2025, Decree of the Government of the Russian Federation of 13.02.2019, № 207-r (version of 30.09.2022), *Digital Repository of Legal and Regulatory-Technical Documents*, URL: https://www.consultant.ru/document/cons_doc_LAW_318094/ (accessed 23.12.2023).

cent years (Table 2), southern regions have been gaining prominence within the Russian space, which is explained by the role these territories have in agricultural exports, logistics and geopolitics [31]. Moreover, southern urban agglomerations, coastal areas and the regions of the North Caucasus have been playing a growing role in the country's demographic landscape.

Table 2

Economic, demographic and settlement shifts in the Russian space between 2015 and 2021

Region	Changes in the contribution of a federal district/region to the national total, percentage points		
	Population	GRP**	Capital investment
Central Federal District, including	+0.154	–0.06	+8.374
Moscow	+0. 247	–0.37	+6.286
Moscow region	+0.281	+0.81	+3.149
Northwestern Federal District, including	+0.082	+2.75	–1.331
St. Petersburg	+0.096	+2.64	–0.119
Leningrad region	+0.093	–0.07	+0.170
Kaliningrad region	+0.034	–0.03	–0.169
Southern Federal District, including	+0.100	–0.49	–1.043
Krasnodar Krai	+0.112	–0.30	–0.564
North Caucasus Federal District	+0.209	–0.38	–0.158
Volga Federal District, including	–0.371	–1.38	–3.188
Tatarstan	+0.024	+0.01	–1.411
Ural Federal District, including	+0.037	+0.01	–4.748
Tyumen region and the autonomous districts	+0.122	+0.47	–4.256
Siberian Federal District	–0.890	–0.38	+0.952
Far Eastern Federal District	–0.058	–0.05	+0.945

Prepared based on Rosstat data (Regions of Russia. Socio-economic indicators, Moscow, *Rosstat*, 2023, p. 43—44, 460—461, 477—478).

Although a statistically significant uprise in investment activity in the Far Eastern and Siberian federal districts (Table 2) is indicative of such a shift, positive changes in the demographic situation, manufacturing and residential development have not yet occurred. Sixteen out of 21 regions of these federal districts are experiencing depopulation. They are still greatly outstripped by the Central federal district, whose industry developed the fastest across the country in 2023. Furthermore, home to 17 % of Russia's population, the two federal districts account for a mere 12 % of newly built residential development.[1] Therefore, it can

[1] Calculated based on data from. Regions of Russia. Socio-economic indicators 2023, *Rosstat*, URL: https://rosstat.gov.ru/storage/mediabank/Region_Pokaz_2023.pdf (accessed 29.12.2023).

be surmised that Russia's incorporation into the structures of the emerging Greater Eurasia is concurrent to a considerable extent with the replication of the country's established territorial-economic and settlement architecture. This concomitance reinforces the Moscow-centrism trends [32] and, in a broader context, a general westward orientation.

The complexity of the Russian space is increasing as a result, adding further to the fundamental contradiction between the Eurasian autonomy of this space and the prospect of a new internationalisation of Russian regions and their municipalities — one that is no longer European but specifically Eurasian. The former phenomenon emerges prominently in the dichotomy between Lesser and Greater Eurasia [8], as well as the prevalent perception of Russia as the 'North' [33] and 'Northern Eurasia' [34]) dominated by centripetal, i. e. capital-oriented, trends, while the latter phenomenon acquires geostrategic multidirectionality as socio-economic disparities and geopolitical risks intensify.

The support framework of Greater Eurasian integration: the Siberian phenomenon

The significance of Siberia for positioning Russia in Greater Eurasia and ensuring the existence of Russian statehood encompasses various dimensions, including historical, geopolitical, economic and military-strategic aspects. Yet, the development of Eurasian partnerships, primarily those with China, requires careful attention to the phenomenon of contemporary Siberia. Perceived today as the mid-Russia [35, p. 93], this region is also seen as the 'core' of Russia's new configuration of the system of Eurasian interactions [36]). It is essential to identify the borders of Siberia, which have been variously defined [37], while simultaneously exploring the possibilities of preserving its demographic landscape, boosting its economic development and ensuring more effective incorporation of the region into the Russian economic and settlement space for the benefit of its residents. These tasks need to be addressed in a systematic yet flexible manner while viewing Siberia as a space bonded by shared history, communication lines and mindset. It is equally important to remember that the unity of Siberian territories is undoubtedly growing in Greater Eurasia. The mega-region of Siberia must be understood in conjunction with its complex geographical structure, diverse conditions, and various formats of spatial socio-economic development. Particular attention should be paid to cross-border regionalization, which is currently gravitating towards the Sino-Russian border, namely the Trans-Siberian Railway belt, and the Arctic zone, where the infrastructure of the Northern Sea Route looms large.

The special status of Siberia is accounted for not only by its proximity to Asia's leading socio-economic powers but also by its predominantly inland position, far removed from ice-free seas, oceans, and major internal and external markets. These factors result in higher transportation costs, which in turn increase

the final prices of products. Despite its harsh climate and low population density over much of its territory, Siberia — the planet's largest landmass — possesses unique resources and raw material wealth and is home to powerful industrial centres. Siberia, particularly the Tyumen region and its autonomous districts, which have recently been economically and geographically gravitating towards Ural, is the largest contributor to the country's budgetary and financial system, providing 45 % of federal tax revenue. As Dmitry Trenin has noted, control over Siberia makes Russia the largest country in the world and ensures its status as a great geopolitical power [38].

The radical change in the geopolitical situation that took place in 2022 unlocked new development opportunities for Russia's eastern inland macro-regions — the Volga region, Ural, Siberia and the Far East — in response to the need for a relatively independent economy. Moreover, promoted as a 'secure strategic rear', these territories have favourable conditions for new industrialisation. The anticipated eastward shift of the economy and production towards Siberia, Ural and the Volga region and the gravitation of transport and logistics to the coastal zones of Russia's Far East will hopefully encourage the population to move in the same direction, albeit on a smaller scale. This change will, in turn, strengthen Russia's standing within the formats of Greater Eurasian partnership.

New positive prospects for the development of Siberia as part of Greater Eurasia are associated with three lines of action [39].

Firstly, there are new opportunities to benefit from continental neighbourhoods: transport corridors linking Siberia to nearby inland markets will significantly reduce transport costs, compensating for constraints on 'plugging' into the global market, which is dominated by developed coastal countries. For example, rail export distances from the central part of Siberia, the Kemerovo region, to the main domestic seaports are colossal: 4,100 km to Baltic Sea ports, 5,000 km to Barents Sea ports and 5,800 km to those of the Sea of Japan. Meanwhile, distances to the capitals of neighbouring countries are significantly shorter: 1,500 km to Astana, 2,700 km to Ulaanbaatar, 2,900 km to Tashkent and 4,000 km to Beijing. Once the planned meridional transport corridors are established, the distances from the Kemerovo region to inland cities of China — Urumqi and Lanzhou — will become shorter compared to domestic seaports. Additionally, the distances to capitals such as Islamabad, Kabul, and Delhi will be relatively similar. Not only are the shipping distances important but also the transport and logistics schemes have significance. The competitiveness of Siberian exports to neighbouring Greater Eurasian countries will be much higher compared to existing arrangements as far as the key transport cost indicator is concerned: additional costs associated with transhipment, lengthy sea passages and subsequent transfer to land transport will be eliminated.

Secondly, closer international cooperation facilitates the processing of Siberian raw materials on-site through organising internationally competitive

high-value-added production and end-product manufacturing, when economically feasible and resources are sufficient. It is necessary to strive for parity in trade and the efficient division of labour between Siberia and Greater Eurasian countries. Proof of the eastern regions' competitive advantage — a phenomenon that still requires, however, a well-thought-out rationale — is the New Angarstroy project seeking to launch the largest full-cycle metallurgical production in Eastern Siberia [40]. This project involves the production and export of high-value-added bulk products to encourage mutually beneficial cooperation between Russia and China.

Thirdly, new international transport corridors are a powerful tool for the economic consolidation of Greater Eurasia's inland territories. Transport along these corridors would be much cheaper than through the rest of the network, and the zones of their immediate influence have the strongest potential for economic development and urban growth. Evolving the Trans-Siberian Railway into a highly efficient corridor requires the construction of a 'super thoroughfare'. New technology solutions should be used to attain this goal, for example, in building elevated tracks. This way, transport costs will be drastically reduced, and transport capacity will significantly increase. The overwhelming impact of ultra-continentality on the Siberian economy will be largely mitigated, and the region's southern latitudinal belt, adjacent to the now modernised Trans-Siberian Railway, will become a priority for 'new industrialisation' through localising processing industries.

Siberia's development within the emerging Greater Eurasia is not without its challenges. Here we will dwell on two of them, one relating to transport and logistics and the other to international trade. The first problem is the difficulty of diversifying raw material export flows to the 'non-Western' world. The scale of the required export reorientation is so monumental that the existing capacities of the railway networks and Far Eastern ports will not be sufficient for a complete redirection of raw material exports to China, India and other Asian countries. The second problem is associated with the risks of trade competition with neighbouring Eurasian countries. For example, due to the similarity in natural resources and export specialisation, Mongolia and the eastern regions of Russia are starting to compete in mineral raw materials markets as suppliers of coal and copper. Both problems can be solved by embracing high-value-added raw material processing thus easing the burden on the transport network, increasing economically viable transport distances and expanding the sizes of market outlets.

Russia's spatial policy should acknowledge the indisputable fact that Siberia is both a national source of raw materials having considerable industrial potential and a supporting macro-region capable of strengthening economic ties with partners in Greater Eurasia. It is essential to recognise that immense Siberian land

is no longer a distant Asian province, but a region that Russia's fate depends on, and its development will be responsible for the country's future prosperity or its demise 41, p. 717].

Moscow-centrism in the multipolar Greater Eurasia: pro et contra

Voices advocating for the relocation of the capital from Moscow to Siberia have resurfaced amid the formation of Greater Eurasia. Proponents of this idea argue that the region is becoming central to the trade flows, as it lies both in the vicinity of key global economic growth points, and, which has become particularly important after the onset of the special military operation, at a considerable distance from unfriendly countries. This discussion reinforces the traditional perception of Moscow as a source of evil for other Russian regions — a city draining them of population and financial resources, ultimately harming the country's economy and itself since it cannot develop rapidly due to excessive population concentration.

Moscow is indeed the main destination of Russian in-migration [42]. According to Rosstat, the continuous increase in population concentration (from 9.068 million at the beginning of 1992 to 13.104 million at the beginning of 2023, or from 6.1 % to 8.9 % of the country's total population) brings not only positive effects but also a host of problems, primarily transport and environmental issues [43; 44]. Moscow has one of the lowest housing availability rates per capita across the nation. Migration from other regions, mainly from nearby Central Russia, to Moscow deprives these territories of part of their workforce necessary for development [45].

Discussed at length in earlier publications [32], Moscow-centricity has been linked to the long-established organisation of Russian society. Despite the inevitability of Moscow-centricity, its adverse effects on the country and the city can and must be mitigated. Current conditions confirm this postulate, providing new arguments in its favour. Neither the largest economy nor the most populated nation of Greater Eurasia, Russia needs to maintain its status and bolster its ability to interact with other Eurasian powers as an equal. A sine qua non here is the involvement of world-ranked global cities, one of which is Moscow [46; 47]. St. Petersburg, another city in Russia enjoying the status, is not a competitor to the capital at the moment. Moscow is the country's hallmark, and no other city — existing or newly built — will compare with it in the foreseeable future.

Moscow-centricity also manifests in the nation's research and technological prowess concentrated in the capital. In 2022, Moscow accounted for 31.1 % of all Russian personnel engaged in research and development, with an additional 12.5 % located in the Moscow region, bringing the total for the capital region to 43.6 %. In St. Petersburg, the figure was 10.5 %, while in the leading eastern

region of the country, Novosibirsk, it was only 3.0 %, placing it fifth in the country after the Nizhny Novgorod region. Given Russia's need to rapidly achieve technological sovereignty, the leading contribution of Moscow and the Moscow region is essential. Moreover, Moscow possesses the necessary high-tech capacities and the potential to further develop them. [48].

Moscow's contribution to national performance and its level of socio-economic development have already been repeatedly discussed in the literature, sometimes in great detail [49]. Yet, to date, there is no compelling evidence that Moscow has exhausted its development potential. Throughout the post-Soviet period, the capital's socio-economic growth has been irregular, at times above and at times below the national averages. These fluctuations can be attributed to objective advantages or limitations, as well as the varying success of Moscow's economic policy. Remarkably, in recent years Moscow has far outstripped an average Russian region in terms of output from industries — unlike GRP, this metric is published promptly, including monthly dynamics, and reflects the situation in the real sector of the economy. The advanced development of the eastern part of the country has not, however, been reflected in the statistics so far (Table 3).

Table 3

Output from major industries, year-on-year, %

Year	Russia	Central federal district	Moscow	Moscow region	Siberian federal district	Far Eastern federal district
2018	103.5	105.0	104.3	111.4	102.7	103.8
2019	102.4	105.5	104.5	110.7	102.6	108.7
2020	98.0	103.2	105.2	106.5	98.3	101.8
2021	106.7	116.6	123.0	123.1	106.0	106.5
2022	99.3	100.2	101.1	98.3	101.6	101.3
2022 on 2017	110.0	133.6	142.6	158.9	111.6	123.9
2023	105.1	111.5	114.9	109.6	99.1	106.3

Prepared based on Rosstat data.[1] The 2023 data are a preliminary assessment.

It is hardly justified to analyse Moscow in isolation from the Moscow region: today the city is typically considered in conjunction with the region within migration and settlement studies, but not those focusing on the economy. For example, the situation with residential construction in the capital region differs substantially from that within the city's official boundaries. Moreover, the perfor-

[1] Rosstat, 2024, URL: https://rosstat.gov.ru/storage/mediabank/IVBO_OKVD2_02-2024.xlsx (accessed 07.04.2024) ; Rosstat, 2024, URL:https://rosstat.gov.ru/storage/mediabank/IVBO-sub-RF_01-2024.xlsx (accessed 07.04.2024).

mance of Moscow itself is far from being a phenomenon subject to unequivocal interpretation. For example, in 2000, the average monetary income per capita in Moscow was 3.5 times the Russian average, but in the last ten years, this ratio has decreased to 2.0—2.2 times, suggesting that the capital has lost some of its advantages. In 2000, the share of remuneration in the population's income was 20 %, with almost 40 % coming from other sources, including hidden income. In recent years, labour remuneration has accounted for about two-thirds of the income, and the ratio of average monthly accrued nominal wages of employees in Moscow to the national average has increased from 1.5 to 1.9—2.0 times.[1] The standards of living in Moscow are higher in many respects than in other regions. Despite environmental problems, life expectancy in the city is second to only that in two North Caucasian republics. Therefore, the capital region is unlikely to lose its attractiveness to migrants in the coming years, with Moscow and the Moscow region accounting for almost 15 % of the Russian population and more than a quarter of the total GRP. The region's leading role in Russia's development also stems from its central position in the country's transport system. Consequently, Moscow will continue to play a primary role in enhancing the much-needed connectivity of Russian territory, especially considering the current and upcoming projects for the construction of transport routes.

The above, however, by no means suggests that there is no need to create conditions for advanced economic development and improved living standards beyond the capital agglomeration — the current geoeconomic and geopolitical situation demands otherwise. Therefore, federal authorities will have to strike a balance in the distribution of budget resources between territories of different types. Nevertheless, Moscow, the capital region as a whole and the entire Central Russia, which is already emerging as a territorial socio-economic entity, will undoubtedly act as one of the key elements in the formation of Greater Eurasia. They are also expected to cement the Russian space, ensuring its integrity in the face of the inevitable growth of exogenous economic and socio-cultural influences brought about by Greater Eurasian integration.

The municipalisation of approaches to strategising in planning spatial development in the context of Greater Eurasian integration. The transformation of the Russian space under the influence of the Greater Eurasia factor amplifies the traditional logic underpinning federal spatial policy. Russia's Spatial Development Strategy (SDS), approved by the Government in early 2019, is set to con-

[1] Calculated by the authors using data from Socio-economic indicators by subjects of the Russian Federation, 2023, *Rosstat*, https://rosstat.gov.ru/folder/210/document/47652 (accessed 30.12.2023).

clude in 2025. The Prime Minister has already commissioned a new concept for this document that would consider current geopolitical challenges and regional and municipal priorities. The Strategy is to be presented in 2024.[1]

The 2019 SDS was the first federal document to explicitly address not only Russian regions and broadly understood macro-regions but also intra-regional differentiation. However, the multi-scale approach was not embraced to its fullest extent at that time. Progress continued along this avenue, and the amendments made to the SDS in 2021 and 2022 somewhat enhanced its municipal focus. We believe that a new SDS will require a heavy emphasis on municipal issues, including those arising in the processes of Eurasian integration.

The radical eastward and southward shift in the structure of Russia's foreign economic relations is primarily discussed by national scholars in terms of the development of the country's macro-regions. However, the impact of the change on larger geographical areas is indirect, while their effect on various municipalities is immediate. Primarily, these are the municipalities that facilitate foreign trade flows by hosting seaports, land border crossings and border logistics centres. The initial version of the SDS categorised entire border regions as geostrategic territories, regardless of the ratio of actual border and non-border areas within them. In 2022, the SDS was supplemented with the concept of 'border municipalities', but even among these, the degree of actual participation in foreign relations varies significantly. Therefore, it is important to identify the type of municipalities performing the essential 'international gateway' function.

A similar situation arises with the development of transport corridors or major transport arteries. Ensuring connectivity between macro-regions and regions, they have an immediate impact on the territories through which they pass. This way, conditions are created for the formation of not only 'points' but also 'axes' of economic growth. The 'development axis' concept is never mentioned in the current SDS, although it is a well-known notion stemming from core-periphery theories. New 'development axes' associated with Greater Eurasia can become hubs for industries supplying domestic and international markets and seeking to maximise the benefits of transport artery construction. Fulfilling this task will likely require additional measures leveraging the advantages of favourable geographical positioning, including, if necessary, the introduction of preferential economic regimes, such as special economic zones and territories of advanced development, and the deployment of necessary infrastructure.

The 'municipalisation' of spatial approaches also has relevance to research and technology policies and national technological sovereignty. Research centres and their related high-tech production facilities are situated in particular loca-

[1] Mikhail Mishustin gave instructions following the strategic session on infrastructure development, 24.11.2023, *Government of Russia*, URL: http://government.ru/news/50202/ (accessed 30.11.2023).

tions, which may not necessarily be major cities or cities officially designated as science cities of which there are only 13 in Russia. Facilitating the development of all Russian science cities, without exception, is crucial and this evolution would be impossible without understanding their actual number, socio-economic status, trends and prospects. The adoption of the SDS was not followed by the creation of an analytical monitoring system for municipal development in Russia, a gap that urgently needs to be bridged.

The formation of Greater Eurasia requires a broader perspective on other types of municipalities as well. For instance, the eastward and southward shift in Russia's spatial structure is expected to strengthen major cities serving as the cores of the corresponding macro-regions; their role in international interactions should also grow. Naturally, Moscow and St. Petersburg must not be the only cities in Russia aspiring to global status. As long as general spatial development trends remain slow-moving, Eurasian integration will alter the overall landscape of municipal differentiation in terms of economic development. This will lead to the emergence of new growth centres, increased migration attractiveness, and, consequently, greater risks of peripheral areas deteriorating. The increasing municipal focus of federal policy, in turn, will require the participation of experts and researchers. Thus, studies on socio-economic geography and regional (spatial) economics need to pay greater attention to the municipal level.

Conclusion

The primary and highly relevant task for Russian social geographers is to overcome the catastrophic lag in understanding the tectonic geo-economic and geopolitical shifts that are radically changing the picture of the world and its geographic aspect by impacting space and giving rise to new territorial-economic and settlement structures and processes. An essential step in this direction is the study of Greater Eurasian integration — a process largely driven by the eastward and southward shift of Eurasia's economic and demographic weight and the conspicuous manifestations of de-globalisation and regional fragmentation catalysed by the conflict between Russia and the collective West. Greater Eurasia poses a significant challenge for researchers due to its complexity: a constantly changing phenomenon of polycentric nature, it is characterised by great diversity, asymmetry, and fluid boundaries. The intricate interaction between Greater Eurasia and the Russian space, which cannot be simplified to a mere part-whole relationship, gives rise to various problem areas and research avenues. In the article, we aimed to highlight the principal ones, which represent merely the tip of the iceberg. The increasing focus on this issue will require refining research approaches through the synthesis of modern global studies (sub-global studies, research into the dynamics and architecture of 'large spaces'), Eurasian studies (in their expanded geographic format), geopolitics, geo-economics, problem-oriented regional stud-

ies, transboundary regional studies and socio-geographic Russian studies with a focus on the country's regions and municipalities. This synthesis is necessary to address both conceptual and practical challenges in strategic spatial development planning.

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References

1. Karaganov, S. A. 2021, Abour the Third Cold War, *Russia in Global Affairs*, vol. 19, № 4, p. 21—34, https://doi.org/10.31278/1810-6439-2021-19-4-21-34 (in Russ.).

2. Druzhinin, A. G. 2021, The ideas of classical Eurasianism and modernity: a human-geographical analysis, Rostov-on-Don, *Southern Federal University*. EDN: KQJEXM (in Russ.).

3. Druzhinin, A. G. 2023, The geopolitical effect of the maritime factor on the spatial development of post-soviet Russia: the Baltic case, *Baltic Region*, vol. 15, № 4, p. 6—23, https://doi.org/10.5922/2079-8555-2023-4-1

4. Vorozheina, Y. A., Klemeshev, A. P., Komleva, N. A., Druzhinin, A. G., Belozerov, V. K., Fedorov, G. M., Voloshenko, K. Yu. 2023, Geopolitical security of Russia: remarks on the problem statement, *Baltic Region*, vol. 15, № 1, p. 153—169, https://doi.org/10.5922/2079-8555-2023-1-9

5. Razumovsky, V. M., Fedorov, G. M., Bezdudnaya, A. G. 2019, Russian Baltics in the Eurasian space (Russia, St. Petersburg, Kaliningrad), *Problems of modern economics*, № 3 (71), p. 38—40. EDN: EXRJHC (in Russ.).

6. Shuper, V. A. 2016, Eurasian Future of Russia: Alternating Integration and Disi integration Cycles, *Baltic Region*, vol. 8, № 4, p. 7—17, https://doi.org/10.5922/2074-9848-2016-4-1

7. Bezrukov, L. A. 2018, The geographical implications of the creation of "Greater Eurasia", *Geography and Natural Resources*, vol. 39, № 4, p. 287—295, https://doi.org/10.1134/S1875372818040017

8. Efremenko, D. V. 2016, The Birth of Greater Eurasia, *Russia in Global Affairs*, vol. 14, № 6, p. 28—45 (in Russ.).

9. Kotlyakov, V. M., Shuper, V. A. 2019, Russia in the Greater Eurasia: mission for the 21st century, *Voprosy geografii*, № 148, p. 357—372. EDN: EUBEPT (in Russ.).

10. Torkunov, A. V., Streltsov, D. V., Koldunova, E. V. 2020, Russia's Pivot to the East: Achievements, Problems, and Prospects, *Polis. Political Studies*, № 5, p. 8—21, https://doi.org/10.17976/jpps/2020.05.02 (in Russ.).

11. Lukin, A. V. 2020, Russia and China in Greater Eurasia, *Polis. Political Studies*, № 5, p. 46—59, https://doi.org/10.17976/jpps/2020.05.04 (in Russ.).

12. Yakovets, Yu. V., Rastvortsev, E. E. 2017, *Great Eurasia: Strategy for Partnership of Civilizations and Unions*, M., SKII (in Russ.).

13. Shuchun, W., Qingsong, W. 2014, Silk road economic belt and EEU — competitors or partners?, *Observer*, № 10 (297), p. 56—68. EDN: STBXCV (in Russ.).

14. Il'in, E. Yu. 2015, The concept of Greater Europe from Lisbon to Vladivostok: problems and perspectives, *MGIMO Review of International Relations*, № 2, p. 84—92. EDN: TVRGZV (in Russ.).

15. Vardomsky, L. B. 2019, Eurasian integration: some results and possible development scenarios, *Russian Foreign Economic Journal*, № 4, p. 110—126. EDN: XKPLFN (in Russ.).

16. Dynkin, A., Telegina, E., Khalova, G. 2018, The Role of the Eurasian Economic Union in the Formation of Great Eurasia, *World Economy and International Relations*, vol. 62, № 4, p. 5—24, https://doi.org/10.20542/0131-2227-2018-62-4-5-24 (in Russ.).

17. Calder, K. E. 2012, The new continentalism: energy and twenty-first-century Eurasian geopolitics, *Yale University Press*, https://doi.org/10.2307/j.ctt1nq6c5

18. Vevier, C. 2004, American Continentalism: An Idea of Expansion, 1845—1910, in: Dudden, A. P. (ed.), *American Empire in the Pacific*, Routledge, https://doi.org/10.4324/9781315262888

19. Gresh, G. F. 2018, Introduction: Why Maritime Eurasia? In: Gresh, G. F. (eds.), *Eurasia's Maritime Rise and Global Security*, Palgrave Studies in Maritime Politics and Security, Palgrave Macmillan, Cham, https://doi.org/10.1007/978-3-319-71806-4_1

20. Gray, C. S. 1988, Ocean and continent in global strategy, *Comparative Strategy*, vol. 7, № 4, p. 439—444.

21. Calder, K. E. 2019, *Super continent: The logic of Eurasian integration*, Stanford University Press.

22. Smith, G. 2004, The masks of Proteus: Russia, geopolitical shift and the new Eurasianism, *Transactions of the Institute of British Geographers*, vol. 24, № 4, p. 481—494, https://doi.org/10.1111/j.0020-2754.1999.t01-2-00481.x

23. Sakwa, R. 2015, Russian Neo-Revisionism and Dilemmas of Eurasian Integration, In: Kanet, R. E., Sussex, M. (eds.), *Power, Politics and Confrontation in Eurasia*, Palgrave Macmillan, London, https://doi.org/10.1007/978-1-137-52367-9_6

24. Zheng, Y. 2021, Rediscovering continentalism: the new geographic foundations of Chinese power, *International Politics*, vol. 58, p. 188—222, https://doi.org/10.1057/s41311-019-00206-7

25. Pepe, J. M. 2018, Beyond China: The Return of the Eurasian Order, In: Schulze, P. W. (eds.), *Multipolarity: The Promise of Disharmony*, p. 211—228.

26. Treivish, A. I. 2009, City, district, country and the world. The development of Russia through the eyes of a country scientist, M., New chronograph. EDN: SUOTFD (in Russ.).

27. Gilmundinov, V. M., Pankova, Yu. V. 2023, Spatial Development of Russia under the Conditions of External and Internal Challenges, *Studies on Russian Economic Development*, vol. 34, № 4, p. 484—491, https://doi.org/10.47711/0868-6351-199-82-93 (in Russ.).

28. Klepach, A., Miheeva, H. 2020, Realities and Opportunities in the Megaproject "Russian Ark", *ECO*, № 8, p. 66—86, https://doi.org/10.30680/ECO0131-7652-2020-8-66-86 (in Russ.).

29. Kryukov, V. A., Seliverstov, V. E. 2022, Strategic planning of the spatial development of Russia and its macro-regions: Captured to old illusions, *Russian Economic Journal*, № 5, p. 22—40. doi.org/10.33983/0130-9757-2022-5-22-40 (in Russ.).

30. Kuznetsova, O. V. 2019, Problems of Elaboration of Spatial Development Strategy of the Russian Federation, *Spatial Economics*, vol. 15, № 4, p. 107—125, https://dx.doi.org/10.14530/se.2019.4.107-125 (in Russ.).

31. Druzhinin, A. G., Kuznetsova, O. V. 2023, The Southern Vector in the Spatial Development of Post-Soviet Russia: the Main Factors and Manifestations, *Federalism*, № 2, p. 5—26, https://doi.org/10.21686/2073-1051-2023-2-5-26 (in Russ.).

32. Druzhinin, A. G. 2018, Prolongation of the "Moscow-Centric" Russian Space: pro et contra, *Polis. Political Studies*, № 5, p. 29—42, https://doi.org/10.17976/jpps/2018.05.04 (in Russ.).

33. Golovnev, A. V. 2022, Northerness of Russia, Saint-Peterburg: Peter the Great Museum of Anthropology and Ethnography (the Kunstkamera) RAS. EDN: WBEYXR (in Russ.).

34. Zamyatin, D. N. 2023, Northern Eurasia at the Junctures of Planetary Geocultures: Co-Spatiality and Borderline, *World Economy and International Relations*, vol. 67, № 7, p. 103—117, https://doi.org/10.20542/0131-2227-2023-67-7-103-117 (in Russ.).

35. Bandman, M. K. 1994, The geopolitical significance of Siberia after the collapse of the USSR, *Izvestiya RAS. Seriya Geograficheskaya*, № 3, p. 85—93 (in Russ.).

36. Kuleshov, V. V., Seliverstov, V. E. 2023, Siberian regions in changing Eurasian relations: navigating new geopolitical and economic realities, *Journal of Siberian Federal University — Humanities and Social Sciences*, vol. 16, № 9, p. 1488—1496. EDN: SEMWYM (in Russ.).

37. Druzhinin, A. G., Dets, I. A. 2021, Problems and prospects of Siberian inland territories' development in the context of Russian marine economic activity, *Czasopismo Geograficzne*, vol. 92, № 1, p. 5—24, https://doi.org/10.12657/czageo-92-01

38. Trenin, D. V. 2021, The new balance of power: Russia in search of a foreign policy balance, M., Alpina Publisher (in Russ.).

39. Bezrukov, L. A. 2019, Eurasian continental integration in the economic and geographical dimension: prerequisites, difficulties, new opportunities, *Voprosy geografii*, № 148, p. 228—262. EDN: DTACGD (in Russ.).

40. Nikolyskiy, A. 2021, What is a Super-combine? *ECO,* vol. 51, № 3, p. 106—121, https://doi.org/10.30680/ECO0131-7652-2021-3-106-121 (in Russ.).

41. Hoesli, E. 2018, L'Epopee Siberienne, Paris, Paulsen (in French).

42. Mkrtchyan, N. V. 2019, Moscow Metropolitan Region as the Largest Center of Internal Migration, *Scientific papers: Institute of National Economic Forecasting of the Russian Academy of Sciences*, vol. 17, p. 252—268, https://doi.org/10.29003/m820.sp_ief_ras2019/252-268 (in Russ.).

43. Revich, B. A., Kuznetsova, O. V. (eds.). 2018, *A man in a megalopolis: Interdisciplinary research experience*, M., URCC. EDN: GVVSQA (in Russ.).

44. Kuznetsova, O. V. 2018, Concentration of economic activity in Moscow and Saint Petersburg: trends, factors, implications for the cities, *Problems of Territory's Development*, № 5 (97), p. 26—40, https://doi.org/10.15838/ptd.2018.5.97.2 (in Russ.).

45. Druzhinin, P. V. 2022, The Resource Concentration in Moscow: Impact on the Economy of the Central Federal District, *Spatial Economics*, vol. 18, № 3, p. 115—140, https://dx.doi.org/10.14530/se.2022.3.115-140 (in Russ.).

46. Homyakova, K. L. 2021, Moscow — a global city: features of development and social problems, *SOCIOLOGY,* № 2, p. 30—35 (in Russ.).

47. Aleksandrova, A. Yu. 2015, Ranking of world global cities as tourist destinations and Moscow particular position, *Regional Studies*, № 3 (49), p. 122—130. EDN: VBLTNJ (in Russ.).

48. Marshova, T. N. 2021, Problems and prospects of Moscow industry development, *Region: Economics and Sociology*, № 4, p. 97—131, https://doi.org/10.15372/REG20210404 (in Russ.).

49. Andronova, L. N., Lantsova, N. M. 2022, Socio-Economic Development Features of Moscow in Current Conditions, *Territorial development issues*, vol. 10, № 1, https://doi.org/10.15838/tdi.2022.1.61.2 (in Russ.).

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SPATIAL AND STRUCTURAL PATTERNS IN THE DISTRIBUTION OF R&D, INNOVATION AND PRODUCTION ACTIVITIES IN RUSSIA

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A modern innovative economy relies on the continual integration of knowledge and technologies into production, monitoring, and management processes. Therefore, territorial proximity and sectoral complementarity of the activities of scientific, technological and industrial organisations are crucial factors in fostering innovation. This article aims to assess the relationship between a region's economic and scientific specialisation and the level of its innovative development. The object of the study is the industrial and research profile of Russian regions' economies with a focus on the strength of connections between them. We identified and measured Russian regions' industry-specific research, technological and economic specialisations. Additionally, we described the spatial and structural patterns of interregional distribution and concentration of research, technological and innovative activities. Methodologically, we compared data on the product output by industry, using the OKVED classification subgroups and information on the costs and implementation of R&D. To gather the latter data, we employed our methodology, which involved juxtaposing GRNTI and OKVED codes. Overall, we analysed data from 17.3 thousand research, development and technological projects conducted between 2017 and 2021 across 18 fields. Specialisation coefficients for both the supply and demand of R&D outcomes and production were computed for each region. The econometric analysis made it possible to distinguish four clusters of regions based on their research and industrial specialisation: agro-industrial regions, mechanical engineering regions, precision engineering regions and diversified regions. The study demonstrated a correlation between a region's innovative product output and the structure of its innovative economy.

Keywords:
knowledge production, geography of knowledge, innovation, regional innovation system, innovation activity, research and development, science and technology

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Introduction and statement of the question

At the present stage, new knowledge is the most important source of innovation and a necessary condition for long-term economic growth. Increasing investment in fundamental research contributes to the expansion of applied developments and an increase in the number of inventions, the introduction of which into production ensures innovative growth [1]. In the 1960s, the function of knowledge production was studied separately [2], but later it began to be considered as an element of economic activity. The ideas of the innovation environment [3], a new model for the functioning of universities as centres for the generation and commercialization of knowledge and technology [4], and wider involvement of representatives of business, government and society in the innovation process [5; 6] were developed.

The neoclassical model of exogenous economic growth, proposed by Solow, identified scientific and technological progress as the main factor-catalyst of economic activity. Scientists associated the free diffusion of knowledge and technologies with their general availability and the achievement of economic interregional convergence with higher growth rates of catching-up regions due to the law of diminishing marginal returns. This assumption was confirmed by empirical studies using the example of Western European countries and the USA [7].

The new theory of endogenous growth, put forward by Romer in the 1980s, made it possible to take into account the economic benefits of investment in research and development (R&D). The economic and geographical studies [8; 9] showed that advanced regions with high levels of R&D expenditure have better economic growth indicators. The presence of territorial patterns in the location of scientific and innovative activity was confirmed when assessing the geographical location of the authors of patent applications in high-tech industries [10].

In the era of digitalization, accelerated movement and simplified access to information in the knowledge production system formed the basis of the concept of open innovation [11]. Increasingly, the results obtained through the research activities of one organisation are applied in the form of innovations in the open market of another. This made it possible to develop the idea of nonlinearity of the innovation process put forward by Schumpeter [12] as well as to substantiate the role of new knowledge as a source of endogenous growth for territorial innovation systems.

The results of some studies [13—15] indicate the presence of 'hotspots' (innovation clusters) and 'voids' (innovation periphery) on the national innovation map. Scientists have substantiated the heterogeneity of scientific and innovative activity and its high territorial localization [16; 17] by using various theoretical and empirical approaches. By using the example of European countries, a positive correlation between the spatial distribution of innovation activity and labour productivity was noted as well as a close relationship between the sectoral specialisation of production and innovation activities [18; 19].

The impact of R&D on productivity and economic growth can vary significantly depending on the industry, the type of R&D, and the source of investment

[1]. The efficiency of investment in research and development is believed to be higher in regions with a specialized economic structure than in those with a diversified one [20]. At the local level, intersectoral knowledge flows also become of great importance for innovation [21]. The key role of the circulation of new knowledge and the effectiveness of its implementation for the development of production was substantiated by the example of Germany [22].

The sectoral specificity of the economic effect of research costs manifests itself both at the international [23; 24] and the interregional [25] levels. The endogenous growth is ensured not only due to a higher concentration of innovations in high-tech segments of the economy but also as a result of their adaptation in other, less technological sectors. Moreover, in the case of such extended countries as Russia, the economic inequality of the regions is extremely high, and the diffusion of innovations primarily affects only the neighbouring territories of the largest cities and the areas of the largest agglomerations [26]. The geographical limitation of the effects of diffusion of knowledge and innovation necessitates the localization of the innovation process in the region.

At the same time, it is important to what extent the region itself can benefit from the knowledge generated in it, which also depends on the ability of local actors and institutions to perceive their economic value [27]. In Russian science, the problem of effective implementation of R&D results into production was noted as early as in the Soviet period (e. g. [28; 29]). An additional complexity is associated with the fact that innovative activity does not always involve the introduction of new scientific developments while the presence of high-tech industries in the region makes the development of science necessary [30].

In this regard, the effectiveness of the regional system for the production of new knowledge and technologies should be assessed along with its production potential. This article continues research in the field of geography of knowledge and is devoted to assessing the territorial and structural patterns of location and concentration of research and industrial activities. The purpose of the article is to assess the connection between the economic and scientific specialisation of a region and the level of its innovative development. The authors set out to determine the role of factors of territorial proximity and industrial diversity in relation to the co-location of R&D and production activities for the innovative development of Russian regions.

Research methods and methodology

The main source of data on civil research, development and technological work (R&D) carried out in Russia within this study was the open database of the Unified State Information System for Research, Development and Technological Work (EGISU R&D). The platform has been developed and is currently administered by the Center for Information Technologies and Systems of the Executive Bodies (FGANU CITiS); it contains information about scientific reports and dissertations published since the beginning of 2014.

During the first stage, all information about starting research projects in *json* format for the period from January 2017 to April 2021 was downloaded from the EGISU R&D database (www.rosrid.ru). The initial set contained information about 66,647 projects, which were selected on the basis of the forms for sending information about the ongoing research, development and technological work for civilian purposes. The following was used from the available information: data on thematic and industry categories (keywords, branches of knowledge according to the GRNTI and OECD rubricator codes); customers and contractors (name and the OGRN code of the organisations); financing (volume and main sources) of each civil research project presented in the database that was underway in Russia during the period under study.

As a result of processing the primary open data of the EGISU R&D, several limitations were identified that acted as limiting factors in the analysis and interpretation of the results of the work. Firstly, the EGISU R&D database contains information only about civilian developments; some double-purpose projects that play an important role in the formation of the research potential of the regions of the Russian Federation were not included in the source data. Since private companies are not required to register their technical developments, a significant part of innovative activity in the non-state sector was also not included in the study. Secondly, some scientific institutions report on the internal research commissioned and carried out within the same organisation. As a result of 'duplicate' reporting in some regions, the amount of R&D financing may be overestimated. Therefore, 'internal' projects were excluded from the analysis. Thirdly, due to the manual filling of data submission forms, the problem of inaccuracies, errors and errata remains. In particular, the most acute problem was the indication of the incorrect amounts of financing for many developments (rubles were used as units of measurement instead of thousand rubles). Manual checks and adjustments of expenses for the largest projects were carried out to verify the data.

At the second stage, the information about organisations participating in R&D as a customer and/or contractor including their registration addresses was downloaded by using the primary state registration number (OGRN) from the SPARK-Interfax database. Based on it and by using geocoding (determining geographic coordinates from unstructured text data), all information was aggregated at the level of regions and municipalities. Spatial reference of R&D was carried out both for contractor organisations and for customers of developments, which made it possible to assess supply and demand in the field of scientific research. Geocoding was carried out by using the Yandex geocoder and the *geo.ru* library in the Python 3.7 programming language.

The third stage of the study included the attribution of R&D to certain types of economic activity in the context of the regions of the Russian Federation. It was carried out by comparing the codes of the GRNTI rubricator at the second level (for example, 68.47 "Forestry") with the names of the subsections of the All-Russian Classifier of Economic Activities (OKVED 02. 'Forestry and logging').

255 thematic subgroups of more than 700 of the GRNTI that had an applied focus were assigned to 18 OKVED groups included in sections A-E, hereinafter referred to as the thematic areas. The determination of the economic specialisation of the regions of the Russian Federation was carried out by using data on the volume of shipped goods of one's own production by subgroups of the OKVED for 2018.[1]

The identification of the industry affiliation of R&D was carried out for the applied research unambiguously identified within a particular group of industries: agriculture, mining and manufacturing industries, and electric power. It turned out to be impossible to connect the remaining areas of scientific knowledge directly with a specific branch of material production since they included predominantly fundamental research that was not directly aimed at practical application. Some projects were also not included in the study sample due to their classification into broader categories of the GRNTI rubricator and interdisciplinary focus. Thus, the final sample included 17,301 projects with a total financing of over 319.9 billion rubles (58.0 % of the total R&D costs for 2017—2021 included in the EGISU R&D). The applied industry research was carried out in all regions of the Russian Federation with the exception of the Nenets and Chukotka Autonomous Districts.

In the fourth stage, the interregional distribution of research and economic specialisations was traced. The research specialisation coefficients were calculated as the ratio of the share of costs for projects in each field of knowledge in the total amount of costs for applied R&D in the region to the share of costs for it in Russia as a whole. The assessment was carried out both for customer organisations (R&D demand) and for contractors (R&D offer). To calculate the economic specialisation coefficients of the regions of the Russian Federation, the volumes of shipped goods of their own production and indicators of gross domestic product (GDP) by type of activity were used. Those for which the values of the calculated coefficients were above 1 were considered to be key specialisations.

In the fifth stage, the statistical analysis methods were used to assess the relationship between the indicators of the costs for completed R&D, commissioned R&D and shipped goods of the regions' own production in the context of 85 regions of the Russian Federation and 18 thematic areas. The analysis was carried out by using the software *StatTech v. 3.1.6*. Since the distribution of the quantitative indicators was different from normal, the direction and strength of pair correlations were assessed by using the Spearman rank correlation coefficient. For the study, only those cases were taken into account when the differences in the quantitative indicators were statistically significant ($p < 0.05$). The interpretation of the strength of the relationship was made according to the Chaddock scale: weak — from 0.1 to 0.3; moderate — from 0.3 to 0.5; significant — from 0.5 to 0.7; high — from 0.7 to 0.9; very high — from 0.9 to 0.99. Further analysis included indicators with a moderate or stronger relationship.

The sixth stage of the study included the interpretation of the results obtained in the previous stages, based on earlier studies that showed the relationship be-

[1] See: Industrial production in Russia — 2019, Statistics/Rosstat. M., 2019. P. 286.

tween industry structure and economic innovation. In particular, the work by Koo [31] substantiates that as the level of knowledge intensity of an industry increases, the influence of factors of diversity and specialisation decreases, and the diffusion of technologies is better ensured between a group of industries with similar knowledge bases. In the article by X. Li [32], based on data from China, it is noted that the occurrence of side technological effects during the clustering of companies is significantly limited if they do not have sustainable practices in conducting research activities. At the same time, the introduction of innovation is facilitated by the presence of local specialisation. Another study [33] showed that a region's industry profile correlates with its domestic resources. The resource dependence of industries determines their concentration within certain geographic boundaries — the locations of these resources. This is also true for technological activities, the development of which is associated with the need for research and innovation resources. Thus, we expect that the level of innovative development of a region will be determined by the structural features of its economy.

At this stage, clustering of the regions of the Russian Federation was carried out by using the methods of econometric analysis according to scientific and industrial specialisation, thereby identifying four clusters. The study is supplemented by an assessment in terms of Federal Districts as units of government and macro-regional territorial communities. A comparison was made as regards the data on industry diversity with the share of innovatively active companies and the share of innovative products in the total volume of goods shipped, work performed, and services provided for the same period 2017—2021. The source of the data was the Rosstat database, 'Science, Innovation, Technology' (URL: https://rosstat.gov.ru/statistics/science). Based on the pair correlation coefficient, the relationship between innovation activity and economic specialisation is assessed to identify the degree of centralization of innovation activity.

The research algorithm is presented in the flow chart (Fig. 1).

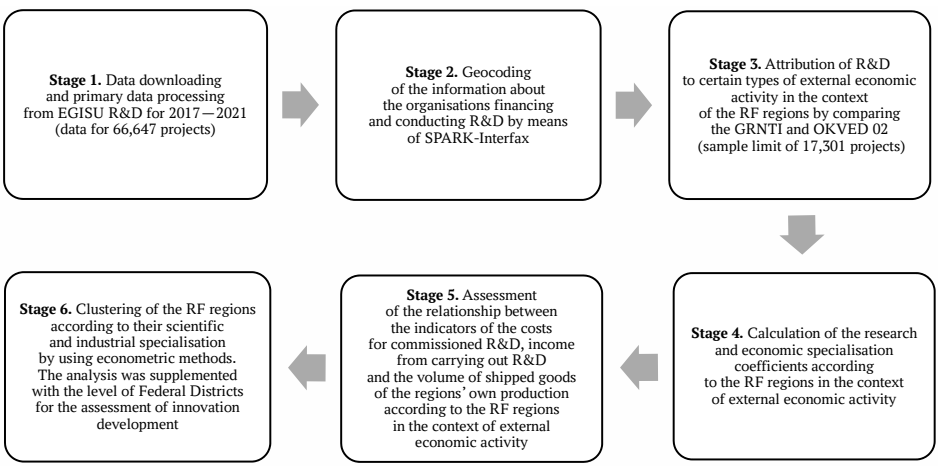

Fig. 1. Flow chart of the methodological stages of the study

Research results

The results of calculating the coefficients of research and economic specialisations of Russian regions made it possible to assess the territorial distribution of the country's scientific and industrial potential (Fig. 2). The geography of the location of organisations — R&D contractors and customers — is characterized by interregional heterogeneity and is also associated with the localisation of industrial production enterprises.

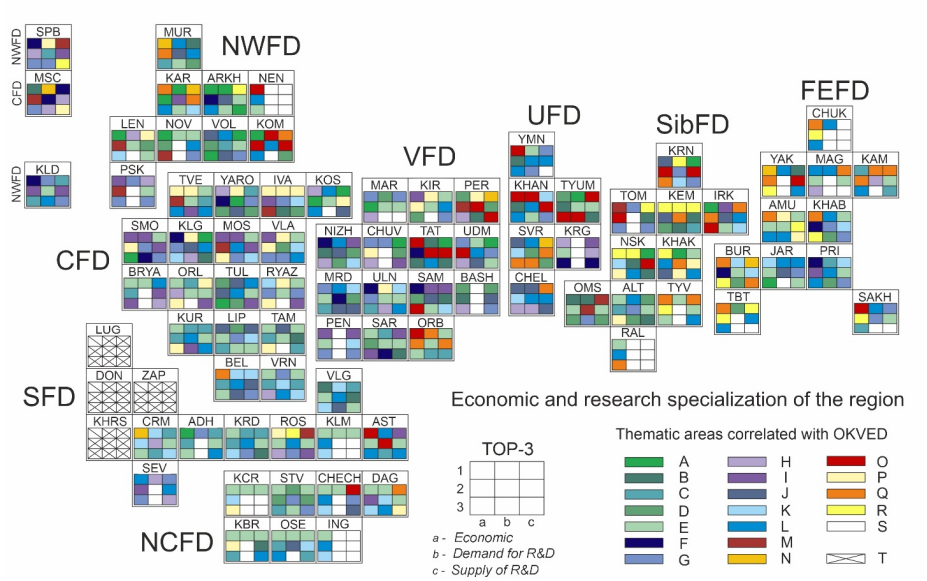

Fig. 2. Distribution of the regions of the Russian Federation by Top-3 leading research and economic specialisations, 2017—2021

Note:

Index of Regions: ALT — Altai Territory; AMU — Amur Region; ARKH — Arkhangelsk Region; AST — Astrakhan Region; BEL — Belgorod Region; BRYA — Bryansk Region; VLA — Vladimir Region; VLG — Volgograd Region; VOL — Vologda Region; VRN — Voronezh Region; MSC — Moscow; SPB — St. Petersburg; SEV — Sevastopol; DON — Donetsk People's Republic; JAR — Jewish Autonomous Region; TBT — Trans-Baikal Territory; ZAP — Zaporozhye Region; IVA — Ivanovo Region; IRK — Irkutsk Region; KBR — Kabardino-Balkarian Republic; KLD — Kaliningrad Region; KLG — Kaluga Region; KAM — Kamchatka Territory; KCR — Karachay-Cherkess Republic; KEM — Kemerovo Region; KIR — Kirov Region; KOS — Kostroma Region; KRD — Krasnodar Region; KRN — Krasnoyarsk Territory; KRG — Kurgan Region; KUR — Kursk Region; LEN — Leningrad Region; LIP — Lipetsk Region; LUG — Lugansk People's Republic; MAG — Magadan Region; MOS — Moscow Region; MUR — Murmansk Region; NEN — Nenets Autonomous District; NIZH — Nizhny Novgorod Region; NOV — Novgorod Region; NSK — Novosibirsk Region; OMS — Omsk Region; ORB — Orenburg Region; ORL — Oryol Region; PEN — Penza Region; PER — Perm Region; PRI — Primorsky Territory; PSK — Pskov Region; ADH — Republic

of Adygea; RAL — Republic of Altai; BASH — Republic of Bashkortostan; BUR — Republic of Buryatia; DAG — Republic of Dagestan; ING — Republic of Ingushetia; KLM — Republic of Kalmykia; KAR — Republic of Karelia; KOM — Komi Republic; CRM — Republic of Crimea; MAR — Republic of Mari El; MRD — Republic of Mordovia; YAK — Republic of Sakha (Yakutia); OSE — Republic of North Ossetia — Alania; TAT — Republic of Tatarstan; TYV — Republic of Tyva; KHAK — Republic of Khakassia; ROS — Rostov Region; RYAZ — Ryazan Region; SAM — Samara Region; SAR — Saratov Region; SAKH — Sakhalin Region; SVR — Sverdlovsk Region; SMO — Smolensk Region; STV — Stavropol Territory; TAM — Tambov Region; TVE — Tver Region; TOM — Tomsk Region; TUL — Tula Region; TYUM — Tyumen Region; UDM — Udmurt Republic; ULN — Ulyanovsk Region; KHAB — Khabarovsk Territory; KHAN — Khanty-Mansiysk Autonomous Okrug — Ugra; KHRS — Kherson Region; CHEL — Chelyabinsk Region; CHECH — Chechen Republic; CHUV — Chuvash Republic; CHUK — Chukotka Autonomous District; YMN — Yamalo-Nenets Autonomous District; YARO — Yaroslavl Region.

Thematic areas correlated with OKVED:

A — wood processing and production of wood and cork products, except furniture, production of straw products and weaving materials, production of paper and paper products; B — production of coke and petroleum products, production of rubber and plastic products; C — production of food products, drinks and tobacco products; D — production of chemicals and chemical products, production of medicines and materials used for medical purposes; E — agriculture; F — printing activities and copying of information media; G — extraction of other minerals; H — crude oil and natural gas production; I — production of textiles, clothing, production of leather and leather goods; J — production of motor vehicles, trailers and semi-trailers; production of other vehicles and equipment; K — production of computers, electronic and optical products; production of electrical equipment; L — production of machinery and equipment not included in other groups; M — furniture production; production of other finished products; N — metallurgical production; production of finished metal products, except machinery and equipment; O — production of other non-metallic mineral products; P — production, transmission and distribution of electricity; Q — mining of metal ores; R — coal mining; S — values of specialisation coefficients below 1; T — no data.

On a macro-regional scale, there are strong differences in the coverage of the thematic areas that occupy leading positions in the economic structure of the Russian Federation regions (Fig. 3). A broader spatial consideration of the Federal Districts made it possible to take into account the proximity of the regions in the assessment of the production processes and scientific and technological processes. The Volga Federal District, Siberian Federal District and Northwestern Federal District are leaders in the share of thematic areas for which higher values of all three calculated specialisation coefficients were obtained than in the Russian Federation. This indicates the concentration of production, research and investment resources within their borders, which favours the development of more knowledge-intensive sectors of the economy. The strongest sectoral focus was noted in the North Caucasus Federal District whose economy is largely represented by extractive activities.

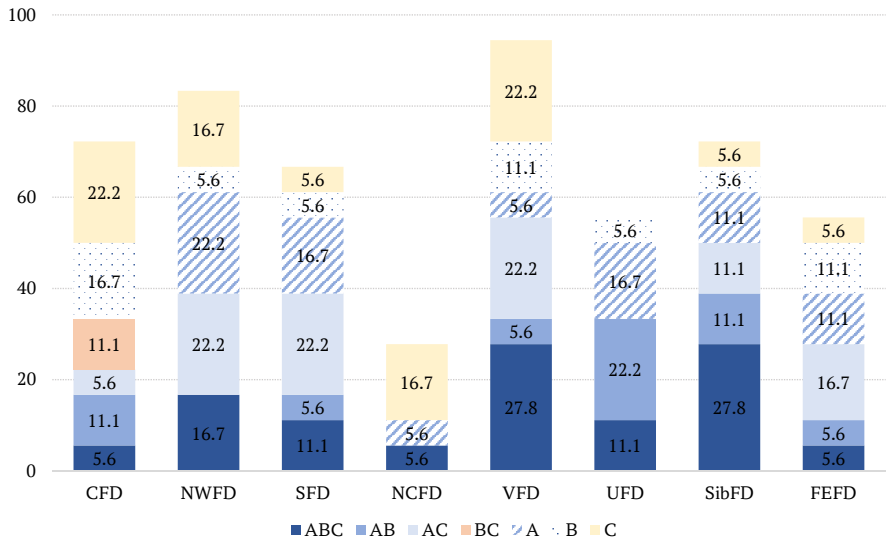

Fig. 3. The share of thematic areas with coefficients of economic and research specialisation above one of the total number of areas in the context of the Federal Districts of Russia in 2017—2021, %

Note. A total of 18 thematic areas were assessed. Specialisations: A — research (R&D offer); B — research (R&D demand); C — economic (volume of output); ABC — values of all three coefficients are above 1; AB / AC / BC — values of two coefficients above 1; A / B / C — the value of only one coefficient is higher than 1.

The calculated indicator of thematic diversity for the Federal Districts of the Russian Federation reveals a high dependence on the indicator of innovative activity of companies (Fig. 4). The pair correlation coefficient is 0.860, which indicates that in the Federal Districts with a greater scientific and production potential there is also a higher concentration of enterprises and organisations engaged in innovative activities. A similar pattern can be noted in relation to the location of small innovative companies (the pair correlation coefficient is 0.798). In other words, the general level of innovation activity is closely related to the localization within geographic boundaries of both the research and industrial base for a wide range of activities.

The less thematic diversity is associated with lower rates of involvement of federal district companies in the innovation process. The Volga Federal District, as a leader among the districts, is characterized by the highest indicators of the complexity of the economic, scientific and technological profile of the regions represented at a high (above the Russian average) level of development of the vast majority of the considered OKVED. On the contrary, the North Caucasus Federal District, which has the lowest level of company innovation, is characterized by a focus on a limited list of specialisations, primarily agriculture.

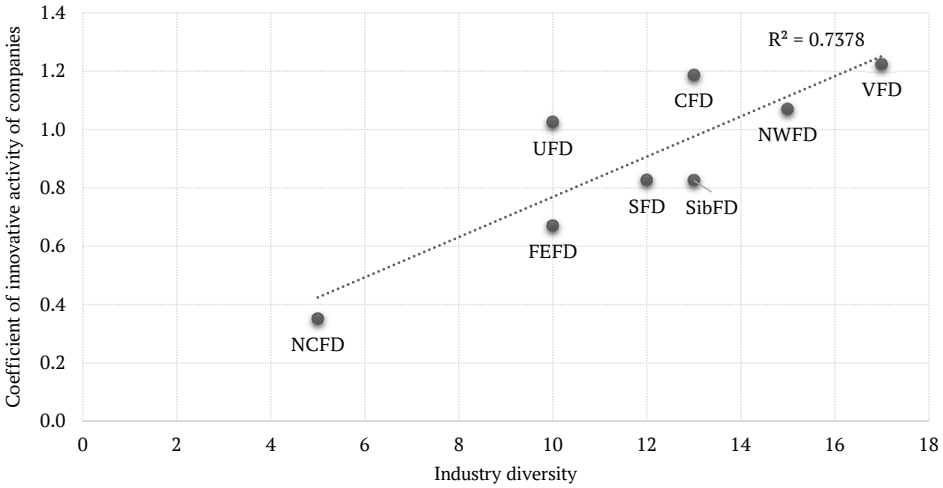

Fig. 4. Distribution of the Federal Districts of Russia
by indicators of thematic diversity and level of innovative activity
of companies in 2017—2021, units

Source: The calculation is based on the data: Science, innovation, technology, Rosstat, URL: https://rosstat.gov.ru/statistics/science (accessed 05.07.2023).

Note. The indicator of thematic diversity is the number of types of activities represented in a Federal District for which at least one of the three specialisation coefficients is above 1. The coefficient of innovative activity of companies in a Federal District is the ratio of the level of innovative activity of companies in the district in relation to the same in the Russian Federation (the average value for the period is calculated).

The relationship between industry diversity and the volume of innovative products (namely: the indicator of the share of innovative products in the total volume of goods shipped, work performed, and services provided for the same period of 2017—2021) is somewhat less strong. The correlation coefficient is 0.524. Despite the fact that the leading positions in terms of innovative product generation are retained by the Volga Federal District, Northwestern Federal District and Central Federal District, a high position is also observed in the North Caucasus Federal District whose economy is characterized by strong industrial centralization. Such a distribution suggests the importance of the composition and structure of the types of activities that form the basis of the economy (it is true for various economic models). To assess the importance of the co-location of the R&D contractor and customer organisations as well as industrial companies in the context of individual thematic areas, the correlation coefficients between indicators of product output, generation and financing of R&D were calculated according to the regions of the Russian Federation (Table 1, Fig. 5).

Table 1

Groups of thematic areas according to the strength of the correlation between the indicators of production volume, generation and financing of R&D in the regions of the Russian Federation in 2017—2021

Indicators	R&D offer — R&D demand	Correlation strength		
		Moderate	Significant	High
		I — A, B, E II — G* IV — R**	I — D	—
	Production volume — R&D offer	I — A, C III — J	I — B, D, E III — K, L, M, N, O, P	—
	Production volume — R&D demand	II — G IV — R	I — A, B, C, D, E II — H	II — F, I

Note.

The letters indicate thematic areas correlated with OKVED. The legend is given in the note to Figure 2.

* the correlation is not statistically significant; ** the correlation is moderately negative.

I — the co-location of research, financing (and setting the thematic agenda) organisations and industrial enterprises is important;

II — industrial enterprises can be remote from research organisations, but co-located with financing organisations;

III — the co-location of industrial enterprises and research organisations is important;

IV — resource-based companies with distributed connections.

The strength of the correlation on the Chaddock scale: moderate — from 0.3 to 0.5; significant — from 0.5 to 0.7; high — from 0.7 to 0.9.

Table 1 and Figure 5 represent the final distribution of the thematic areas under study in four groups:

— first (I) — with the potential of key actors in the innovation process for clustering in the region, including manufacturing enterprises; organisations that create demand for scientific achievements by financing R&D; research and development organisations;

second (II) — with the potential for the formation of innovation networks, when production enterprises and organisations conducting R&D can be located in different regions, but the diffusion of new knowledge and innovation between them is ensured (in this case, the need for R&D (commission) comes from the region where industrial capacities are concentrated);

— third (III) — with the potential for the formation of localized scientific and production ties, including those with external financial support (the economic specialisation stimulating the development of research can be primary for the region and vice versa);

— fourth (IV) — with low innovative potential (in our study, these are dependent on natural resources).

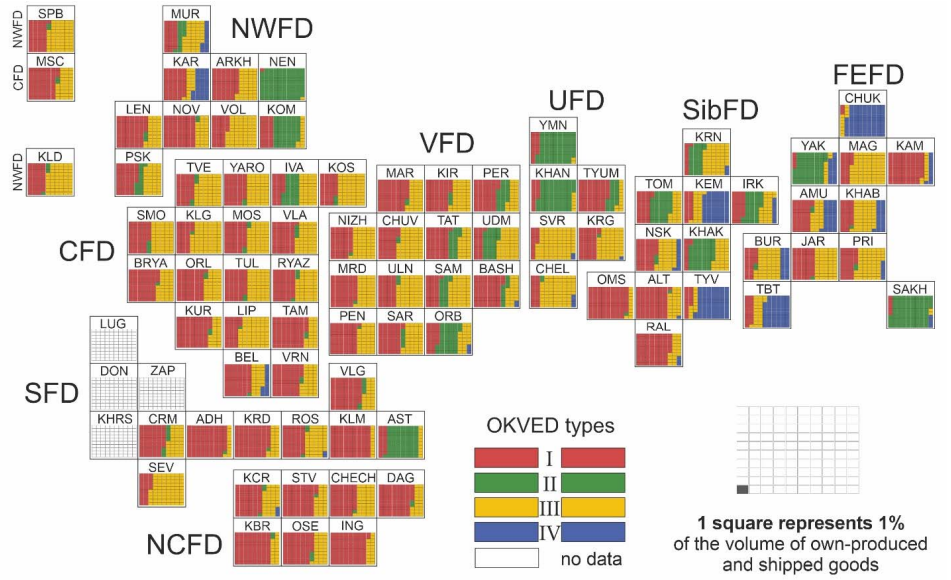

Fig. 5. Groups of thematic areas by regions of Russia according to the volume of produced and shipped goods. One square represents 1 % of the volume of own-produced and shipped goods

The first and third groups of the thematic areas (the second somewhat less) are focused on the localization of innovative activity or its individual processes. This was reflected in the calculated correlation coefficients (Table 2). We can assume that the prevalence of the thematic areas of the first and third groups in research and economic specialisations is positively related to the overall level of innovative development of the region while the high share of the fourth group of the thematic areas, on the contrary, does not contribute to the growth of innovation in the economy.

Table 2

Coefficients of pair correlation between innovation indicators and economic structure indicators using the example of Federal Districts

Share in the economic structure	Groups of thematic areas	Innovation indicators		
		Share of innovatively active companies	Share of innovative goods in the total volume of shipped goods	Diversity of thematic areas
	I	0.799	0.579	0.899
	II	0.806	0.439	0.884
	III	0.903	0.581	0.958
	IV	–0.449	–0.398	–0.115

Figure 6 demonstrates the differences in the structure of the economy of the Federal Districts of Russia in the context of selected groups. The example of the Far Eastern Federal District and Ural Federal District is illustrative. While having the same number of thematic areas, the Federal Districts are characterized by different innovative efficiency: the Far Eastern Federal District is inferior to the Ural Federal District in terms of the share of innovative goods and innovative activity of companies. This can be explained by qualitative differences in the structure of their economic systems: in the Ural Federal District there is a higher share of thematic areas of groups I and III while in the Far Eastern Federal District, a significant share falls on the less knowledge-intensive groups II and IV. In other words, for the innovation profile of a macroregion, not only the quantitative diversity of industries is important (the desire to expand specialisations and accumulate various knowledge bases), but also the level of their knowledge intensity. An imbalance towards a greater representation of low-tech activities, the development of which does not require the localization of the corresponding research base, does not contribute to strengthening the territorial innovation system and increasing the overall level of innovation in the economy.

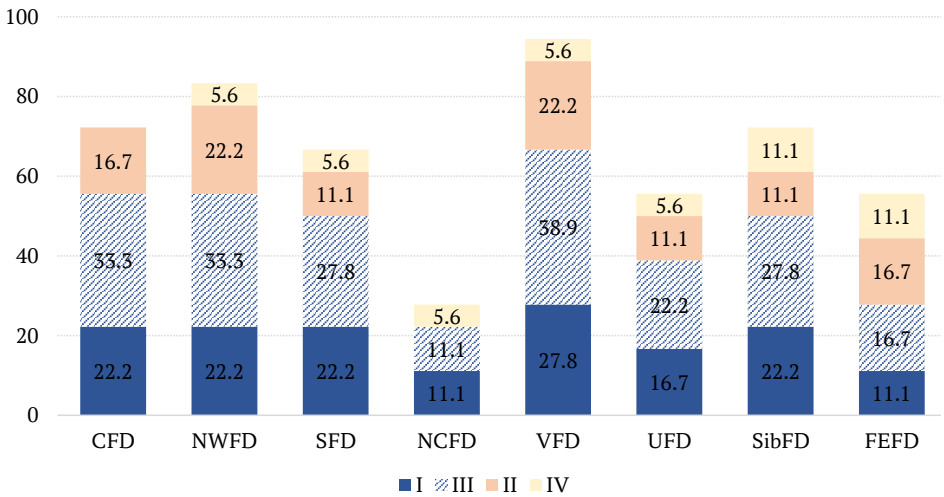

Fig. 6. Distribution of the thematic areas with coefficients of economic and research specialisation above one by group according to the Federal Districts of Russia in 2017—2021, %

Note: The descriptions of groups I, II, III, and IV are given in Table 1.

Geographic diversity is more typical of innovative groups I and III of the thematic areas — there are several centres of economic growth within a Federal District (Fig. 7) while the prevalence of the thematic areas of groups II and IV in the structure of the economic system is associated with stronger geographic

centralization. In terms of individual types of activities, the largest number of the regions of the Russian Federation are involved in the generation of knowledge and innovation in agriculture, and the smallest number is in the mining of coal and other minerals.

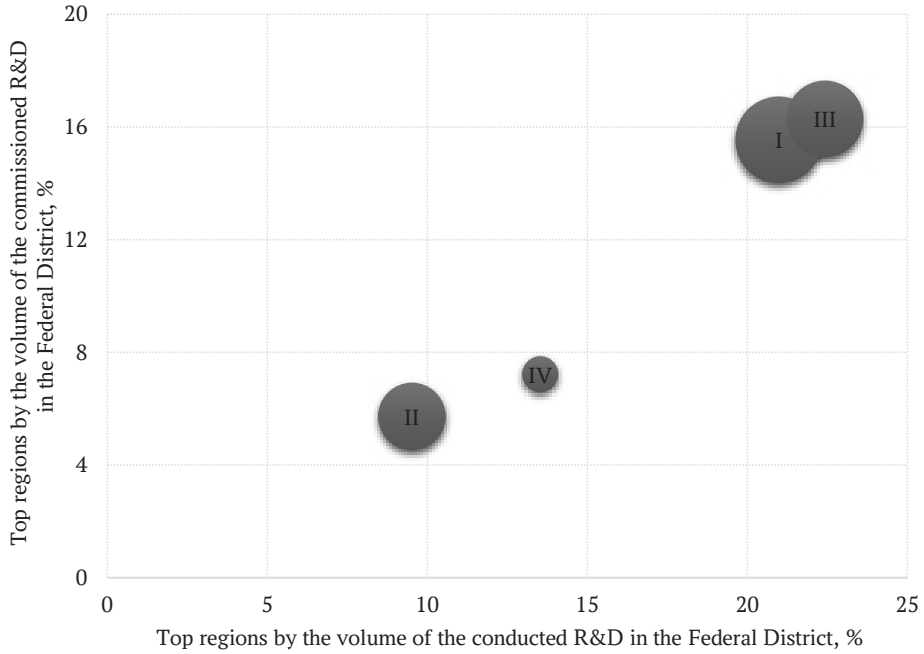

Fig. 7. Distribution of groups I—IV of the thematic areas in relation to the indicators of geographic centralization of research and industrial activity in the Federal Districts of the Russian Federation in 2017—2021, %

Note. The diameter of the punch indicates the share of regions leading in terms of product output in the Federal District (FD) of their total number in the FD. The leading regions for each indicator were defined as those whose share is at least 10 % of the values for the Federal District.

On average, for one customer region, there are 1.4 and 1.6 contractor regions for groups I and III of the thematic areas, while for groups II and IV of the thematic areas, this figure is higher — 2.5 and 1.8 contractor regions respectively. Thus, groups II and IV of the OKVED are characterized by a higher degree of geographic concentration of R&D financing. Similarly, when assessing the number of production regions per R&D contractor region, the leadership belongs to group II of the thematic areas (3.1) and the second place is occupied by the OKVED of groups I and III (1.7 and 1.3, respectively). As for the OKVED of group IV, the number of regions-generators of scientific knowledge and product manufacturers is almost equal (0.9).

The use of Federal Districts as units for description and analysis, despite their obvious internal economic and geographical heterogeneity, has its prerequisites. Aggregating data by Federal District simplifies the process of interpreting data within territorial communities. An alternative could be economic regions or additionally constructed territorial clusters, but a Federal District seems to be the most suitable territorial unit for the study. This is primarily due to the fact that Federal Districts are the units of government,[1] which means that the findings obtained in the work can be adapted to support decision-making on the development of scientific and technological policy by the federal and regional authorities.

At the same time, a typology of regions based on their scientific specialisation was constructed during the work. This typology is an alternative to the analysis at the level of Federal Districts. It makes it possible to develop measures to support science and technology proceeding from the objective prerequisites for focal economic development and territorial irregularity of R&D demand and offer and to optimize the selections of regions for piloting measures to stimulate scientific activity. To form a typology of the Russian regions by research specialisation, a cluster analysis of the structure of research carried out in the region was conducted by using the k-means method. As a result, four clusters of regions were identified with similar parameters of specialisation of the R&D sector (Fig. 8, Table 3).

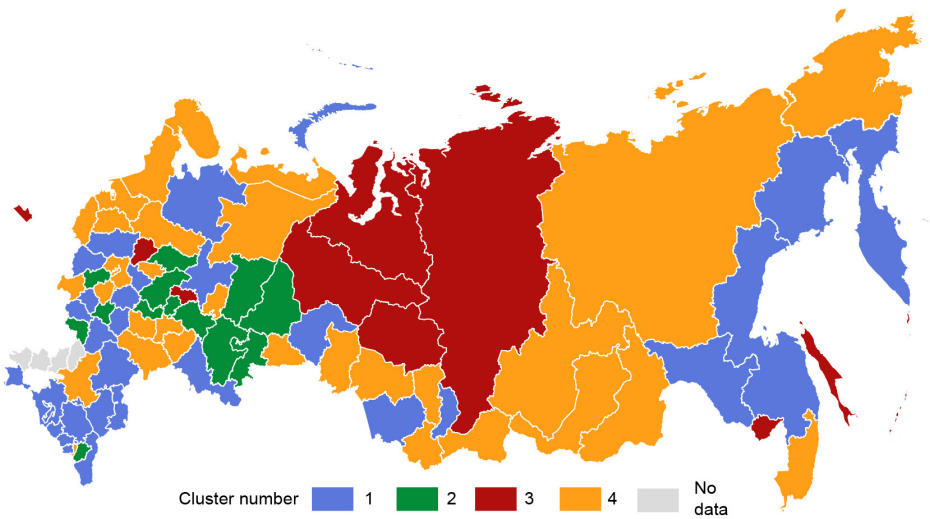

Fig. 8. Clustering of regions by using the k-means method based on the scientific and industrial specialisation

[1] Instruction of the Government of Russia of 23 August, 2021 'On the decisions following the outcome of the meeting on the institution of the supervisory control over the Federal Districts by Vice-Prime Ministers of the Russian Federation'.

Table 3

Shares of the key industries in the structure of R&D implementation in cluster centres, %

Economic activities	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Production of petroleum products	0.9	1.3	0.7	2.4
Food industry	3.9	0.3	1.8	0.8
Chemical industry	2	17.1	2	3.8
Agriculture	75.8	11.2	8.9	24.5
Extraction of other minerals	0	0.5	0.2	0.9
Production of vehicles	0.4	2.3	0.2	5.4
Production of computers	6.5	16.8	60.3	14.8
Production of machinery and equipment	0.5	4.1	3.7	6.9
Furniture production	1.3	2.9	1.8	3
Metallurgical production	1.1	24.5	3.3	3.8
Production of other non-metallic products	0.6	3.9	1.4	2
Power industry	3.9	11.3	14.5	13.9
Mining of metal ores	2.3	1.4	0	2.5
Coal mining	0.2	0	0.1	1.9
Crude oil and natural gas production	0.4	1.6	1.2	1
Wood processing	0	0.7	0	0.1
Textile, clothing and footwear industry	0.1	0.1	0	0.2
Printing activities	0	0	0	0

Cluster 1 (agro-industrial): It includes regions with a developed research infrastructure in agriculture and fisheries. Their predominance in the overall structure is largely due to the location of specialized institutes and research centres as well as large agricultural universities.

Cluster 2 (mechanical engineering): Large centres of metallurgy and mechanical engineering located in these regions serve their own needs for innovation on the basis of the existing network of higher education institutions and research centres.

Cluster 3 (precision engineering): It was identified on the basis of the predominance of computer technology developments aimed at federal customers. The developed research centres included in this cluster create demand from federal agencies and corporations. The key oil and gas-producing regions are primarily acceptors of innovation and do not have a self-sufficient infrastructure for conducting R&D.

Cluster 4 (diversified): This cluster includes both the innovative periphery and large centres with a diversified R&D structure. Regions of the innovation periphery do not have a pronounced specialisation. In addition to them, Cluster 4 includes several regions with centres of competence in two or more areas (the Vologda, Irkutsk, Moscow, Rostov Regions, etc.), which could not be included in other groups due to their diversity.

The discussion of the results

The study of spatial patterns of innovation activity is carried out in line with two main approaches. The Marshall-Arrow-Romer approach assumes that innovative effects on the economy are produced through the concentration of several

main activities in the region. Such specialisation, subject to a common labour market and the use of internal resources, creates favourable conditions for the flow of knowledge and technology between industrial companies, which contributes to their innovation and economic growth. An alternative view draws primarily on the ideas of Jacobs and Porter and focuses on the importance of cross-industry diversity within geographically determined boundaries. This gives impetus to innovative activity through the development of the relationship of competition and cooperation between companies of different but often complementary activities.

The comparison of the performance indicators (for example, labour productivity, employment, output, etc.) with the implemented economic model in different spatiotemporal contexts does not provide a clear answer about the best approach to regional development. Such factors as the existing institutional environment [32]; the availability of resources in the region to diversify the production structure [34]; the level of development and maturity of specific types of activities; the degree of specialisation of the region [35]; the presence of specialized scientific and educational institutions that meet the needs of the economy and can strengthen innovative potential and act as drivers of innovative development of the region [36] and others are of great importance.

This study is limited by the use of generalized statistical data on economic, scientific and technological activities in the regions of the Russian Federation due to the lack of information on the actual interaction between scientific and industrial enterprises. The fact that a region has developed similar research and industrial specialisations only indicates the localization of certain competencies, knowledge and infrastructure in it, but does not prove the mutual integration of local business and science. A detailed consideration of various factors influencing industry and territorial proximity is possible only when using cases of individual regions with examples of enterprises.

Scientific and production ties can also be established between organisations with close geographical locations but with different administrative and territorial affiliations (for example, in the regions of the Russian Federation bordering each other). Such cooperation networks are of high importance in the interregional division of labour but are not the object of study in this work. This limitation is partially mitigated by additional consideration of the macro-regional context of scientific and industrial activity within the boundaries of the Federal Districts.

Another limiting factor in the study, which provides room for further scientific research, is the difficulty in considering the introduction of secondary innovations from other industries as the basis for the development of breakthrough innovations at the present stage. Methodologically, such ‘borrowings’ are difficult to predict since interactions are irregular and indirect in the form of a flow of new knowledge. In this context, the mapping of thematic and sectoral areas carried out in this work is a complex and non-trivial task. The authors are aware of the

attempts to compare types of economic activity and scientific areas in other countries, but this experience cannot be fully applied to Russia which uses its own classifiers (GRNTI, OKVED).

Conclusion

The relationship between research activity, innovation activity and economic growth is non-linear. However, it is the ability to generate and commercialize new knowledge that is the key driver of regional development. The analysis of the geography of scientific research and industrial activity made it possible to assess the relationship between the economic and research specialisation of the Russian regions considering the structural differences of their economies. A positive relationship has been identified between the diversity of the thematic areas being developed in the region (in both research and economic terms) and the level of innovation activity. It is shown that in relation to the volume of output of innovative products, not only the number of leading types of activity plays a role but also the structure of the innovative economy that has developed in the region. The volume of output of innovative products is higher where a structure of an innovative economy exists. From this perspective, both a model of wide diversity and a model of a limited number of economic specialisations can be effective. Strengthening research and innovation activity, along with intensifying inter-organisational connections, creates conditions for sustainable industrial development.

The findings provide scope for further research in the field of the geography of knowledge and innovation. Below are just a few promising areas that, in our opinion, should be focused on in future work.

Firstly, it is necessary to continue work to determine the optimal criteria for the relationship between concentration and localization of research and production activities from the perspective of enhancing innovation in the region. Modern research on new industrial districts [37] supports the Marshall-Arrow-Romer approach to the importance of specialisation. At the same time, several other studies indicate the importance of 'unrelated variety' [38] and 'cross-fertilization' [39] for making breakthrough innovations, which proves the importance of cross-sectoral ties. It is important to develop a territorially adaptive approach to organizing new spatial forms of innovation activity taking into account local and industry-specific features of the innovation process.

Secondly, it is necessary to supplement current studies with an assessment of the dependence of the scientific, technological and innovation profile of a region on the level of its intellectual capital. Some earlier studies (for example, [36]) establish the relationship between the development of higher education, economic development and innovation: a higher educational institution attracts high-tech production and R&D thus creating the prerequisites for the development of a particular economy in the region, and the structure of economy determines the structure of training specialists for the corresponding profile. However, with modern

advances in the information and communication sphere and transport, the distributed interregional network connections are also capable of ensuring a sufficient level of knowledge flow and diffusion of innovations through labour migration and the formation of informal business networks. It can be assumed that 'temporary clusters [40] and organisational-cognitive proximity [41] can, under certain conditions, neutralize the factor of territorial remoteness of scientific, technological and industrial infrastructure, but this issue requires more careful study.

Thirdly, a more in-depth study of the processes of diffusion of knowledge and technology at the cross-sectoral level is required. The study shows that the economic specialisation of a region makes it possible to consolidate internal resources in just a few key activities. At the same time, the scientific sector ensures the development of primarily high-tech industries [42]. In this regard, the effects of co-development of high-tech and low-tech activities within the boundaries of the general innovation system of the region require additional study.

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References

1. Rodríguez-Pose, A., Crescenzi, R. 2008, Research and development, spillovers, innovation systems, and the genesis of regional growth in Europe, *Regional Studies*, vol. 42, № 1, p. 51—67, https://doi.org/10.1080/00343400701654186

2. Machlup, F. 1962, *The production and distribution of knowledge in the United States*, Princeton, Princeton university press.

3. Hessels, L. K., Van Lente, H. 2008, Re-thinking new knowledge production: A literature review and a research agenda, *Research policy*, vol. 37, № 4, p. 740—760, https://doi.org/10.1016/j.respol.2008.01.008

4. Karpov, A. 2017, Modern university as an economic growth driver: Models & missions, *Voprosy Ekonomiki*, № 3, p. 58—76, https://doi.org/10.32609/0042-8736-2017-3-58-76 (in Russ.).

5. 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*, vol. 46, № 3-4, p. 201—234, https://doi.org/10.1504/ijtm.2009.023374

6. Cai, Y., Etzkowitz, H. 2020, Theorizing the triple helix model: Past, present, and future, *Triple Helix*, vol. 7, № 2-3, p. 189—226, https://doi.org/10.1163/21971927-bja10003

7. Andrews, M. J., Whalley, A. 2022, 150 years of the geography of innovation, *Regional Science and Urban Economics*, vol. 94, № 103627, https://doi.org/10.1016/j.regsciurbeco.2020.103627

8. Debresson, C. 1989, Breeding innovation clusters: A source of dynamic development, *World Development*, vol. 17, № 1, p. 1—16, https://doi.org/10.1016/0305-750X(89)90218-0

9. Malecki, E. J. 1981, Science, technology, and regional economic development: Review and prospects, *Research Policy*, vol. 10, № 4, p. 312—334, https://doi.org/10.1016/0048-7333(81)90017-2

10. Moretti, E. 2021, The effect of high-tech clusters on the productivity of top inventors, *American Economic Review*, vol. 111, № 10, p. 3328—3375, https://doi.org/10.1257/AER.20191277

11. Chesbrough, H. 2019, *Open innovation results: Going beyond the hype and getting down to business*, Oxford, Oxford University Press, https://doi.org/10.1093/oso/9780198841906.001.0001

12. Schumpeter, J. A. 1939, *Business cycles: A theoretical, historical, and statistical analysis of the capitalist process*, New York, McGraw-Hill.

13. Kourtit, K., Nijkamp, P. 2013, Introduction: Regional innovation hotspots and spatial development, *Journal of Regional Science*, vol. 53, № 5, p. 745—748, https://doi.org/10.1111/jors.12078

14. Mikhaylov, 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 Obrazovania*, vol. 41, № 5, p. 549—563, https://doi.org/10.32744/pse.2019.5.39

15. Baburin, V. L. 2022, Center-peripheral features of the placement of Russian industry, *Trends in the Spatial Development of Modern Russia and Priorities of its Regulation*, Tyumen, Tyumen state university Press, p. 17—22. EDN: QFWHUC

16. Feldman, M. P., Kogler, D. F. 2010, Stylized facts in the geography of innovation, In: Hall, B. H., Rosenberg, N. (eds.), *Handbook of the economics of innovation*, North-Holland: Elsevier, p. 381—410, https://doi.org/10.1016/S0169-7218(10)01008-7

17. Simmie, J. 2003, Innovation and agglomeration theory, In: Simmie, J. (ed.), *Innovative cities*, London, Routledge, p. 9—52, https://doi.org/10.4324/9780203165478

18. Moreno, R., Paci, R., Usai, S. 2005, Geographical and sectoral clusters of innovation in Europe, *Annals of Regional Science*, vol. 39, № 4, p. 715—739, https://doi.org/10.1007/s00168-005-0021-y

19. Zitt, M., Barré, R., Sigogneau, A., Laville, F. 1999, Territorial concentration and evolution of science and technology activities in the European Union: A descriptive analysis, *Research Policy*, vol. 28, № 5, p. 545—562, https://doi.org/10.1016/S0048-7333(99)00012-8

20. Aarstad, J., Kvitastein, O. A. 2020, Enterprise R&D investments, product innovation and the regional industry structure, *Regional Studies*, vol. 54, № 3, p. 366—376, https://doi.org/10.1080/00343404.2019.1624712

21. Koo, J., Kim, T. 2009, When R&D matters for regional growth: A tripod approach, *Papers in Regional Science*, vol. 88, № 4, p. 825—840, https://doi.org/10.1111/j.1435-5957.2009.00261.x

22. Audretsch, D. B., Keilbach, M. 2007, The localisation of entrepreneurship capital: Evidence from Germany, *Papers in Regional Science*, vol. 86, № 3, p. 351—365, https://doi.org/10.1111/j.1435-5957.2007.00131.x

23. Griffith, R., Redding, S., Van Reenen, J. 2004, Mapping the two faces of R&D: Productivity growth in a panel of OECD industries, *Review of Economics and Statistics*, vol. 86, № 4, p. 883—895, https://doi.org/10.1162/0034653043125194

24. O'Mahony, M., Timmer, M. P. 2009, Output, input and productivity measures at the industry level: The EU KLEMS Database, *The Economic Journal*, vol. 119, № 538 119 (538), p. 374—403, https://doi.org/10.1111/j.1468-0297.2009.02280.x

25. Badinger, H., Egger, P. H., von Ehrlich, M. 2019, Productivity growth, human capital and technology spillovers: Nonparametric evidence for EU regions, *Oxford Bulletin of Economics and Statistics*, vol. 81, № 4, p. 768—779, https://doi.org/10.1111/obes.12285

26. Zubarevich, N. V. 2017, Development of the Russian space: barriers and opportunities for regional policy, *The world of new economy*, vol. 11, № 2, p. 46—57. EDN: YSPLCJ (in Russ.).

27. Cohen, W. M., Levinthal, D. A. 1990, Absorptive capacity: A new perspective on learning and innovation, *Administrative Science Quarterly*, vol. 35, № 1, p. 128—152, https://doi.org/10.2307/2393553

28. Safonova, L. I. 1972, Vnedrenie rezul'tatov zakonchennyh nauchnyh issledovanij v proizvodstvo [Introduction of the results of completed scientific research into production], *Bulletin of the Tomsk Polytechnic University. Geo Assets Engineering*, № 255, p. 65—71 (in Russ.).

29. Tonkikh, Yu. A. 1972, Proizvodstvennoe osvoenie dostizhenij nauki i tekhniki [Industrial development of achievements of science and technology], *Bulletin of the Tomsk Polytechnic University. Geo Assets Engineering*, № 255, p. 57—64 (in Russ.).

30. Kuznetsova, O. V. 2022, Development of science in the regions: actual problems of evaluation, *Borderland Issues*, *New Trajectories of International Cooperation, Kaliningrad: IKBFU Press*, p. 43—47. EDN: ZYHIUQ (in Russ.).

31. Koo, J. 2007, Determinants of localized technology spillovers: Role of regional and industrial attributes, *Regional Studies*, vol. 41, № 7, p. 995—1011, https://doi.org/10.1080/00343400601142746

32. Li, X. 2015, Specialization, institutions and innovation within China's regional innovation systems, *Technological Forecasting and Social Change*, vol. 100, p. 130—139, https://doi.org/10.1016/j.techfore.2015.06.032

33. Lu, Z., Deng, X. 2017, Regional specialization: New methods of measurement and the trends in China 1987—2007, *Applied Econometrics and International Development*, vol. 17, № 2, p. 119—140.

34. Kowalewski, J. 2011, Specialization and employment development in Germany: An analysis at the regional level, *Papers in Regional Science*, vol. 90, № 4, p. 789—811, https://doi.org/10.1111/j.1435-5957.2011.00355.x

35. Katrovsky, A. P. 2018, Higher school as a factor in the economic development of Russian regions bordering Belarus, In: Popkova, L. I., Madra, C., Vardomsky, L. B. (eds.), *Strategy for the Development of Border Territories: Traditions and Innovations,* p. 48—54. EDN: YXPEZF (in Russ.).

36. Katrovsky, A. P., Baranovsky, I. Yu., Vatlina, T. V., Evdokimov, S. P., Shcherbakova, S. A., Yaskova, T. I. 2022, *Spatial organization of higher education and regional development*, Smolensk: Publishing house of Smolensk State University. EDN: ZDMGOA (in Russ).

37. Markusen, A. 2017, Sticky places in slippery space: A typology of industrial districts, In: Martin, R. (ed.), Economy: *Critical essays in human geography*, London, Routledge, p. 177—197, https://doi.org/10.4324/9781351159203

38. Castaldi, C., Frenken, K., Los, B. 2015, Related variety, unrelated variety and technological breakthroughs: An analysis of US state-level patenting, *Regional Studies*, vol. 49, № 5, p. 767—781, https://doi.org/10.1080/00343404.2014.940305

39. Bailey, D., Pitelis, C., Tomlinson, P. R. 2020, Strategic management and regional industrial strategy: Cross-fertilization to mutual advantage, *Regional Studies*, vol. 54, № 5, p. 647—659, https://doi.org/10.1080/00343404.2019.1619927

40. Maskell, P., Bathelt, H., Malmberg, A. 2006, Building global knowledge pipelines: The role of temporary clusters, *European Planning Studies*, vol. 14, № 8, p. 997—1013, https://doi.org/10.1080/09654310600852332

41. Boschma, R. A. 2005, Proximity and innovation: A critical assessment, *Regional Studies*, vol. 39, № 1, p. 61—74, https://doi.org/10.1080/0034340052000320887

42. Golova, I. M., Sukhovey, A. F. 2019, Differentiation of Innovative Development Strategies Considering Specific Characteristics of the Russian Regions, *Economy of regions*, vol. 15, № 4, p. 1294—1308, https://doi.org/10.17059/2019-4-25 (in. Russ.).

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ANTHROPOGENIC AND NATURAL FACTORS SHAPING THE BOUNDARIES OF THE ST. PETERSBURG SUBURBAN AREA

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The suburban area of St. Petersburg stands out as Russia's most complex in terms of spatial structure, encompassing districts ranging from the suburban imperial residences of the 18th century to low-rise residential zones and modern multi-storey developments of the 21st century. This study concluded that extensive stretches of the administrative border between St. Petersburg and the Leningrad region divide homogeneous territories. Therefore, it makes little academic or practical sense to confine scholarly efforts solely to suburbs situated on one side of this border. The principal factor in delineating the St. Petersburg urban area is the transport accessibility of territories surrounding the city. It was empirically determined that the inner boundary of the suburban area is located approximately within the 40—45-minute isochrone from the city centre, while the outer boundary extends to the 2-hour isochrone. In the conditions of today's St. Petersburg, a two-hour isochrone corresponds to a 60 km distance. Along with isochrones, the actual boundary of the suburban area is determined by several natural and anthropogenic factors.

In terms of the natural environment, a significant part of the St. Petersburg suburban area is anthropogenic forest-steppe, whose landscapes are radically different from those of the area's natural southern taiga subzone. The features of the 'forest steppe' reach their peak to the southwest and south of St. Petersburg. To the north of the city, the suburban zone is defined by both 'anthropogenic forest-steppe' and secondary small-leaved forests that have replaced agricultural lands. Another prominent feature is parks found on the premises of former estates where introduced woody species account for a substantial portion of vegetation. The spatial structure of the suburban area north of St. Petersburg is complicated by large extents of unpopulated areas. Since the 19th century, they have divided the area into two virtually disconnected parts.

Keywords:
Saint Petersburg, Leningrad region, borders, suburban area

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Introduction

Relevance. Russia has undergone rapid suburbanisation in recent decades, with suburban areas developing around all cities of the country. These zones are as diverse as cities themselves. The suburbs of Moscow and St. Petersburg began to emerge in the second half of the 19th century and have undergone numerous changes over the centuries, including significant spatial transformations.

The suburban area of St. Petersburg is the most complex in terms of its spatial structure not only in Russia but also across the former Soviet Union. The 'museum suburbs' (formerly towns of the Palace Administration) coexist with various historical and residential developments. These include former imperial dacha settlements, factory villages from the interwar period, military towns that played crucial roles during the Great Patriotic War and remained largely intact until the early 21st century, and detached housing areas from the 1950s. Additionally, there are settlements from the 1960s and 1970s dominated by Khrushchev-era apartment buildings, 1980s settlements featuring Brezhnev-era buildings, and entirely new suburban settlements that sprang up during the post-Soviet period. Over more than a century, the functions of the suburban zone's various segments have evolved, and these changes continue to this day. These circumstances make the suburban zone of St. Petersburg and its spatial development a highly fascinating subject for research. However, despite its intrigue, it remains poorly studied from a geographical perspective.

The study aims to delineate the suburban area of St. Petersburg and describe the conditions and factors contributing to its emergence. Anthropogenic factors in this process include the transport system and settlement patterns in areas adjacent to St. Petersburg. Natural factors encompass landscapes that either hinder or promote the formation of suburbs. In this context, anthropogenic landscapes also warrant consideration.

Literature review

The US stands out as the undisputed leader and pioneer in suburban studies, a distinction owing to its status as a 'nation of suburbs'. In 1950, 27 % of the US population lived in the suburbs, and by 2002, this figure had risen to 52 % [1]. Not only are these areas home to a substantial part of the populace, but they also offer ample job opportunities.[1]

[1] Wendell Cox. Suburbs (Continue to) Dominate Jobs and Job Growth, 2016, *Newgeography,* URL: http://www.newgeography.com/content/005264-suburbs-continue-dominate-jobs-and-job-growth (accessed 16.03.2024).

In the mid-1980s, Kenneth T. Jackson [2] carried out a historical study of suburbanisation in the US, investigating a period from the mid-19th century to the 1980s. His monograph, whose findings remain relevant to this day, is entitled *Crabgrass Frontier: The Suburbanization of the United States* with a reference to both the American frontier and the lawn-ruining weed that was a symbol of suburban life from 1945 to the early 1970s.[1] Jackson views suburbs as a 'new frontier', the 'American dream' come true in the form of a house and a lawn. The Australian researcher Lionel Frost [4] echoes this viewpoint, as seen in his book *New Urban Frontier: Urbanisation and City Building in Australasia and the American West,* where he presents the findings of his exploration of suburbs in the Pacific coast states. According to Frost, the emergence of the 'new urban frontier' at the turn of the 19th and 20th centuries marked the beginning of American-style suburbanisation, which continues to this day.

Nowhere else in the world are suburban area structures as complex as in the US. American scientists have developed a detailed classification of these zones, introducing concepts such as 'boomburb', 'edge city', 'greenfields', and 'uptown'. A *boomburb* is a swiftly developing part of the suburban zone; an *edge city*, located in the outer peripheral part of the suburban zone, serves as an alternative urban centre; *greenfields* are new suburban settlements created from scratch; an *uptown* is a pun used to refer to the opposite of 'downtown'. Unlike greenfields, uptowns are 'old' settlements that fit in seamlessly in the new suburban settlement system [5].

Yet suburbs were not an exclusively US phenomenon: during the second half of the 20th century, Western and Eastern Europe, as well as the Soviet Union, experienced suburbanisation. Suburbanisation in Europe and the USSR was comprehensively described by academics from across the region. In Western Europe, the term 'peri-urbanisation', originating in France in 1976, gained widespread usage. Various publications define it as in-migration from large cities to small towns and rural areas, the latter gradually acquiring urban features (see [7—9]). Therefore, some of its instances can be termed 'ruralisation', which is characteristic of many European countries (see [10; 11]). However, the relationship between ruralisation and peri-urbanisation in Europe, considering the relatively short domestic distances, sometimes remains unclear.

In Asia, suburbanisation follows a trajectory distinctly different from that of the US and Western Europe. In the 1980s, the Canadian-based New Zealand geographer Terry McGee proposed the term '*desakota*' ('city-village' in the Indo-

[1] Jackson. K. T. 2020, On the Urbanist Classic, "Crabgrass Frontier", *Fieldstead and Company,* URL: https://www.fieldstead.com/post/on-the-urbanist-classic-crabgrass-frontier (accessed 15.03.2024).

nesian language) to refer to Eastern Asian suburbanisation [12]. Although not very common, it sometimes appears in the Russian literature [13]. Later, McGee developed a classification of *desakotas* [14].

There are at least three types of urbanisation:

1. Suburbanisation per se, or American suburbanisation, involves the 'outward' expansion of cities, driven by the availability of sparsely inhabited areas. Such suburban areas are primarily formed through the establishment of new urban settlements, characterized in the case of the US by low-rise residential areas and predominantly multi-story office, commercial, and industrial developments. Suburbs may also incorporate pre-existing urban and rural settlements, whose functions change dramatically in the process.

2. Peri-urbanisation, or European suburbanisation, is migration from large cities to small towns and rural settlements, resulting in significant changes to the built environment. The space between the cities and nascent suburbs may see further development in the future, or it may remain intact. Peri-urbanisation is a response to limited space conditions, leading to the emergence of low-rise (less often) and multi-story (more frequently) development areas. In other words, while American suburbanisation involves creating new settlements and gradually integrating existing ones, European suburbanisation entails migration from cities to already established settlements, leading to radical transformations, and the subsequent development of the space between them.

3. *Desakota*, or Asian suburbanisation, involves the formation of extensive rural areas in the vicinity of large cities, these areas having very few urban features if any at all. Economically, *desakota* residents can be engaged in activities typical of both urban and rural zones. Like in the US, low-rise buildings are typical in *desakota* areas; however, they signify poverty rather than affluence.

Although other types of suburbanization may exist, a typology of this process lies beyond the scope of this study. The three types listed above are of interest to our research as all of them are observed in Russia today.

Predominant types of suburbanisation vary across the country as the process may occur according to the American (suburbanisation), European (peri-urbanisation) or Asian (*desakota*) model or a combination of these. Since the demise of the USSR, Buryatia has seen rapid urbanisation. The capital of the republic, Ulan-Ude, is surrounded by predominantly rural-type development areas, which attract people from across the region [15]. For example, Anatoly Breslavsky notes that rural migrants predominated among the new residents who settled in the suburban areas of Ulan-Ude between the 1990s and 2010s, accounting for 92.3 % in 2014. These migrants typically had average to below-average incomes [16, p. 98]. Therefore, one can conclude that suburbanisation in Ulan-Ude fol-

lows the Asian *desakota* model, with suburban zones maintaining a rural character in both settlement patterns and residents' occupations. Similar processes take place in Yakutia [17]. A blend of all three suburbanisation types is characteristic of large cities in European Russia [18; 19].

Yet some researchers argue that, in the case of Russia, the emergence of so-called dacha territories is tantamount to suburbanisation (see [20]). It is important to distinguish between two separate phenomena. The first is 'dacha settlements' proper, built from the late 19th century [21] to the 1950s—1960s, which have permanent residents. The second involves areas managed by 'gardening non-profit associations'. Federal Law № 217-FZ of July 29, 2017 'On Horticulture and Gardening by Citizens for Personal Needs and on Amending Certain Legislative Acts of the Russian Federation',[1] does not consider lands of such associations as settlements. Suburbanisation, however, entails the formation of a system of settlements, which dachas are not unequivocally classified as, even if they have a year-round population.

The development of the suburban area of St. Petersburg primarily followed the European suburbanisation (or peri-urbanisation) model, building on an established network of settlements. Yet a *desakota* admixture was also evident. Since the beginning of the 21st century, American-style suburbanisation has become dominant, with rapid property development occurring in the in-between areas, integrating them with pre-existing settlements. In addition, there are myriads of non-commercial gardening associations within urban areas. Created in the 1950s and 1960s, they are now surrounded by urban housing. A prime example is the grounds of the Kirov Plant Gardening Association, located between Prospekt Veteranov and Prospekt Narodnogo Opolcheniya in the city's south-west.[2] As a result, identifying the current boundaries of the suburban area of St. Petersburg is often an intricate task.

Materials and methods. The main method used in this study was fieldwork. The first stage of the research involved determining the actual administrative border between St. Petersburg and the Leningrad region. Forty-six reference points were selected along the northern, eastern, and southern directions of the administrative border, pinpointing areas where the most significant disparities between the de jure and de factor boundaries were observed (Fig. 1).

[1] On the conduct of gardening and horticulture by citizens for personal needs and on amending certain legislative acts of the Russian Federation: federal law of 29.07.2017 № 217-FZ 2017, *President of Russia,* URL: http://www.kremlin.ru/acts/bank/42175 (accessed 16.03.2024).

[2] Gardens in the shadow of the Trilogy residential development, 2015, *Nedvizhimost' i stroitel'stvo Peterburga* [*Real estate and construction of St. Petersburg*], URL: https://nsp.ru/19979-ogorody-v-teni-trilogii (accessed 27.03.2024).

Fig. 1. Reference points on the border between St. Petersburg and the Leningrad region. The map was prepared by Ivan Grekov (2023)

A visual assessment revealed numerous discrepancies between the borders of the city and the region as depicted on various mapping platforms (Yandex Maps, *Google Maps*).

Key results. The suburban area of St. Petersburg encompasses two main types of territories. Firstly, it includes territories on either side of the boundary between the city and the Leningrad region where this border aligns with the former border between the region's territories under the authority of the Leningrad City Council of People's Deputies (from 1991 to 1995, the Administration of St. Petersburg) and the remaining region. Secondly, it comprises the territory extending only towards the region, where the region borders the 'city of republican subordination' of Leningrad (since 1991, St. Petersburg). This understanding of the 'suburban zone' contradicts the widely spread but entirely

incorrect notion of it as a territory directly adjacent to the administrative border between St. Petersburg and the Leningrad Region but located entirely outside the city [22].

The administrative border between St. Petersburg and the Leningrad region formed over several decades, from 1931 to 1976. It has a very intricate nature, sometimes splitting settlements where one part belongs to St. Petersburg and the other to the Leningrad region. Sometimes parts of these divided settlements even have different names (Fig. 2).

Fig. 2. Sovkhoznyaya St. runs through the area,
with the village of Osinovaya Roshcha located
to the left (in St. Petersburg, Vyborg district) and the village of Yukki situated
to the right (in the Leningrad region, Vsevolozhsk district).
Photo by Vasiliy Martynov (2023)

In some cases, *vice versa*, the administrative border between St. Petersburg and the Leningrad region divides completely unpopulated territories. This is the case, for example, along most of the border between the city's Kurortny district and the Vyborg district of the Leningrad region (Fig. 3).

Fig. 3. The Gladyshevka river. St. Petersburg
and its Kurortny district are located to the right of the waterway
and the Leningrad region and the Vyborg district are to the left.
Photo by Vasiliy Martynov (2023)

Moreover, areas that differ strikingly in terms of property development may co-exist within suburban municipalities, ranging from unpopulated, waterlogged or forested areas to state-of-the-art residential and industrial districts. A prime example is two neighbouring municipalities within the city's Vyborg district, which adjoin the border with the Leningrad region: the villages of Pargolovo and Levashovo. The population of the Pargolovo municipality has increased approximately 6.5-fold over the 21st century, from 16,000 people in 2012 to 106,155 people in 2023 and continues to grow. The spatial structure of this municipality is quite unique. Its central part, occupying most of the village's area, is dominated by individual housing built from the 1930s to 1960s with an addition of post-Soviet cottages. To the south and north of the centre, there are areas of 21st-century high-rise property development located at considerable distances from each other. These are the buildings that appeared near the Parnas metro station, replacing abandoned lots and demolished garages, as well as the new districts of the village of Osinovaya Roshcha and the new development areas in Mikhaylovka, formerly agricultural lands (Fig. 4).

Fig. 4. The Pargolovo and Levashovo municipalities
of St. Petersburg's Vyborg district and their high-rise property development areas.
Prepared by Tatiana Andreeva (2023)

The population of the municipality of Levashovo was approximately 3.7 thousand people in 2012 and about 6 thousand people in 2023, nearly doubling over the period. The substantial disparities in population growth rates are largely due to natural conditions. The village of Levashovo has little room for multi-storey development as half of its territory is occupied by forests and marshlands, some of which constitute the Levashovo Memorial Cemetery — a former NKVD execution site where tens of thousands of victims of Stalinist repressions were buried in the 1930s. The non-forested and undeveloped part of Levashovo, located to the north of the ring road and clearly visible on the map above, is the construction site of the new Levashovo airport.

Thus, establishing the boundaries of the suburban zone of St. Petersburg is a complex task. The boundaries between the suburban zone of Leningrad and St. Petersburg were never formally established, unlike in Moscow. For Russia's capital and the adjacent region, the 1980 boundaries were described as follows: 'The suburban zone is the territory of the Moscow region within the Moscow agglomeration, within a radius of 60—70 km from the borders of the city…'.[1] Yet, although both outer and interior borders require delineation, only the external one was defined.

The current plan of St. Petersburg sets the administrative border as the foundation for the city's interaction with the region. It designates a 'zone of influ-

[1] Suburban area. *Online version of the Moscow encyclopedia, the 1980 edition*, URL: https://www.mos80.ru/p/poklonnaya_prjevalskiy/suburban_zone.html (accessed 17.03.2024).

ence between St. Petersburg and the Leningrad region', extending 5 km from the city's border towards the region. However, the map presented in this plan draws the boundary of the 'influence zone' at varying distances from the administrative border, sometimes — as in the case of the north of the Vyborg district — cutting through the territory of St. Petersburg.[1] The plan does not specifically address the suburban area but rather mentions the St. Petersburg agglomeration, with various definitions provided for its boundaries within the document. Denis Olifir defines the St. Petersburg agglomeration as encompassing the territory of the Leningrad region from the state border to the eastern boundaries of the Volkhov and Kirishi districts, excluding the Slantsy and Luga municipalities, with a total area of approximately 39,000 km^2. According to Leonid Losin and Viktor Solodilov, the agglomeration is much smaller, covering an area of 11,600 km^2, with St. Petersburg occupying about 1,400 km^2 of that total [23]. The agglomeration sketch map they developed in 2019 was republished in 2022 with no significant alterations, and the accompanying text remained largely unchanged as well [25].

The boundaries of the agglomeration proposed by Losin and Solodilov was used by Elena Lapshina in her delimitation of the area. She writes that 'the suburban area of St. Petersburg includes territories of the Leningrad region bordering the city (the Vsevolozhsk, Vyborg, Kirovsk, Tosno, Gatchina and Lomonosov municipalities), the Priozersky district as well as some districts of St. Petersburg dominated by individual housing development (the Kurortny, Pushkin, Peterhof, Primorsky, Vyborg and Kolpino districts)' [26, p. 99]. Without delving into the specifics of the agglomeration boundaries, it is worth noting that automatically extending them to the suburban area is hardly justified. Such a definition would expand the suburban area to encompass the entire Karelian Isthmus, from Lake Ladoga to the Finnish border. This would mean its outer northwestern boundary is roughly 150 km from St. Petersburg, while the southeastern border aligns with the boundary between the Leningrad and Novgorod regions, approximately 120 km from the city. The St. Petersburg suburbs cannot extend to such remote areas, as the socio-economic viability of the territory and population diminishes as the distance from the agglomeration centre increases, leading to a reduction in its area. As Pavel Druzhinin notes, 'creating a comfortable environment in an agglomeration requires significant resources, and the larger the agglomeration, the larger their share should be. Since the territory of an agglomeration grows faster than its population, sectors of the economy servicing the agglomeration grow more rapidly than innovative industries, and labour productivity in the ag-

[1] General plan of St. Petersburg (2023), *Government of St. Petersburg. Committee for Urban Planning and Architecture,* URL: https://kgainfo.spb.ru/fb/share/kfc7vUk7 (accessed 17.03.2024).

glomerations increases slowly' [27, p. 154]. Put simply, the farther a settlement is from the main city within an agglomeration, the more energy it needs to maintain communication with the centre and the less it invests in its own development. This statement seems to apply to the processes of both agglomeration and suburbanisation.

Ilya Reznikov while not addressing the suburban area *per se*, considers nevertheless the boundaries of the so-called 'first belt of the St. Petersburg agglomeration', which can be identified with the suburban area. Reznikov includes in this belt territories limited by the village of Privetninsky on the northern coast of the Gulf of Finland, the town of Sosnovy Bor on its southern coast, the Siverskaya station of the Oktyabrskaya Railway, the Vyritsa station of the Vitebsk stretch of the railway, the Fornosovo station of the St. Petersburg—Novgorod stretches, the Ushaki station of the Moscow stretch, the village of Priladozhsky on the shore of Lake Ladoga and the village of Lembolovo north of the city [28].

As previously empirically established [19], the boundary between the city proper and the suburban area is defined by the 45—50-minute transport isochrone. As of 2024, this corresponds to a distance of approximately 20—22 km from the center of St. Petersburg, assumed to be located at Kazan Square or Nevsky Prospect near the Kazan Cathedral. The 40-minute isochrone has served as the interior boundary of the suburban area throughout the entire 20th century and into the present years of the 21st century. The distance it defines changes, however, as transport develops and its speeds grow.

The outer boundary of the suburban area is roughly determined by the two-hour transport isochrone, which corresponds to a distance of 50—60 km in the St. Petersburg suburban area. Thus, the outer boundary of the area is located now at approximately the same distance from the city centre as the outer boundary of the Moscow suburban area was forty years ago. This correspondence can be logically explained by St. Petersburg's overall lag behind Moscow in urban planning terms.

As the 40—45-minute isochrone has persisted as the interior boundary for more than a century from the turn of the 19th and 20th centuries, the two-hour isochrone has served as the outer boundary for the same length of time. Yet, the distance that can be covered in two hours changes with the development of transport, and accordingly, both the inner and outer boundaries of the suburban zone alter.

It is noteworthy that the part of the *de jure* territory of St. Petersburg lying outside the two-hour isochrone is *de facto* located outside the outer boundary of the suburban zone. Indeed, along the southern coast of the Gulf of Finland, the suburban area stretches only as far as the Oranienbaum-1 (Lomonosov) station, and along the northern coast, it extends no farther than the Zelenogorsk station.

Fig. 5. The border between St. Petersburg
and the Leningrad region is near Bronka station,
about 50 km away from the centre of St. Petersburg.
The distance to the border of urban property development at Oranienbaum-1 station
is approximately 10 km. Photo by Vasiliy Martynov (2023)

The actual outer boundary of the suburban area follows a significantly more complex path than the two-hour isochrone due to the transport and natural features of the territory. The border runs closest to the isochrone in the south-west, between Lomonosov and Gatchina. A characteristic feature of this boundary is that it has a well-defined natural component: the inhabited territory there is non-forested, falling under the definition of 'anthropogenic forest-steppe'. The forest vegetation is predominantly of secondary growth, while the 'forest-steppe' itself is of exclusively anthropogenic origin: without human interference, the area would be overgrown with southern taiga vegetation. Due to the nature of the relief and soil, pine forests are expected to dominate on the uplands, while spruce forests would be more prevalent in the depressions.

To the north and east of the city, the 'anthropogenic forest-steppe' does not constitute a continuous feature due to the more complex terrain compared to the southern part, which is dominated by a continuous homogeneous plain and broken ground. However, 'anthropogenic forest-steppe' is also present in areas that have favourable conditions for property development, acting as a reliable marker of a territory's reclamation status and whether it can be identified with the suburban zone (Fig. 6).

Fig. 6. The 'anthropogenic forest-steppe' near of Skvoritsy vilagge, Gatchina district. Photo of Vasilii Martynov (2024)

The dry, well-drained territories south of the Gulf of Finland have long been an attractive place to settle. Before the Great Patriotic War, when the local rural population consisted mainly of Ingrian Finns (as evidenced by remaining toponyms, church buildings and cemeteries), there were many more rural settlements in this area than there are today, and the rural population density was higher. It was probably then that the 'anthropogenic forest-steppes' began to emerge. In any case, they can already be visible on the maps of the late 19th century.

This area boasts very favourable natural conditions, which is apparent from the fact that all of the preserved imperial country estates are located within its boundaries: Peterhof, Gatchina, and Tsarskoe Selo (known today as Pushkin). Although some researchers define Peterhof as a recreational town [22], such classification is entirely incorrect. The town has no recreational function today, being a prominent tourist attraction. At the same time, its main purpose today is industrial. Until the beginning of the 21st century, the town's principal enterprise was the Petrodvorets watch factory [28]. However, at the turn of the century, the formation of a large industrial zone began, involving the neighbouring parts of Peterhof and Strelna [29].

This is a densely populated area, almost completely bereft of forests or marshes, where something resembling natural vegetation can only be seen in the parks: the celebrated Lower Park is dominated by dark coniferous species typical of

southern taiga wetlands. North of Gatchina, the suburban area boundary extends in the northeastern direction towards Pavlovsk, running along the left bank of the Izhora.

As one moves away from Izhora, the area becomes increasingly swampy, naturally resulting in a sparser population. From the Izhora Valley, the border of the suburban zone extends into the Tosna River basin. Following the river, it ascends to the town of Tosno, then, tracing the river's path once more, it heads northward to the right bank of the Neva River (the town of Otradnoye). Continuing in a narrow strip along the Schlisselburg road, it extends to the town of Schlisselburg, situated at the source of the Neva River on the shore of Lake Ladoga. Between the watershed of the Izhora and Tosna rivers and the shore of Lake Ladoga, there are vast swampy areas virtually unsuitable for settlement. There are few settlements here, the largest one is the village of Mga. Having originated as a junction railway station, the village has been fulfilling this sole function up to the present time. Unlike the settlements of the suburban area, it has very few quotidian connections with St. Petersburg.

To the north of the Gulf of Finland and the Neva River, the boundary of the suburban area is even more intricate than in its southern part. The 'anthropogenic forest-steppe' areas, though present, do not extend uniformly in all directions. Instead, they form a continuous mass stretching up to approximately 22—23 km from the centre of St. Petersburg. In the south-west of the suburban area, the boundaries of this non-forested zone extend in some places up to about 45—50 km from the city centre, as can be seen south of Gatchina. The 'anthropogenic forest-steppe' reaches its maximum breadth in the Vyborg direction and along the former Irinovskaya railway, built in the late 19th century, or, as an alternative delineation, along the new Murmansk motorway running parallel to it since the 1980s. In both scenarios, the creation of vast non-forested zones dates back to the agrarian development of the area between the 17th century and the first half of the 20th century. During this period, the territory was primarily inhabited by Ingrian Finns, whose settlements covered most of the zone.

The area's woody vegetation is mostly accounted for by secondary small-leaved forests, which have overgrown the former agricultural lands, and the successfully introduced species of estate parks (Fig. 7).

The areas adjacent to the coastlines of the Gulf of Finland, Lake Ladoga, and the Neva River are characterized by extensive waterlogging, with numerous small watercourses flowing from the interior parts of the area. The inland area, characterized by undulating lacustrine relief, retains remnants of agrarian development from past centuries. Subsequently, dacha settlements emerged in this area [31], some of them replaced now by large-scale residential developments.

Fig. 7. The Siberian larch (*larix sibirica*), an introduced woody species,
in the semi-abandoned manor park of Osinovaya Roshcha,
the Vyborg district of St. Petersburg.
Photo by Vasiliy Martynov (2024)

The north of the St. Petersburg suburban area occupies the southern part of the Karelian Isthmus, whose relief is remarkably diverse: the depression skirting the shore of the Gulf of Finland is replaced by uplands in the centre and yet another depression towards the coast of Lake Ladoga. The relief significantly influences the layout of the transport network, thereby shaping the settlement system. The outer boundaries of the suburban area exhibit a distinct star-like pattern, with one arm tracing along the Gulf of Finland (Primorskoe motorway and the Finnish railway), another following the Vyborg motorway, a third extending along the Priozerskoe and Novo-Priozerskoe motorways and a fourth running along the Murmansk motorway. There is a large gap in the settlement system there, accounted for by an area that is neither populated nor involved in the transport network [32]. As a result, the outer boundary of the suburban area extends southward towards St. Petersburg, stretching from the city's southern end to the shore of Lake Ladoga, north of the Borisova Griva railway station (Fig. 8).

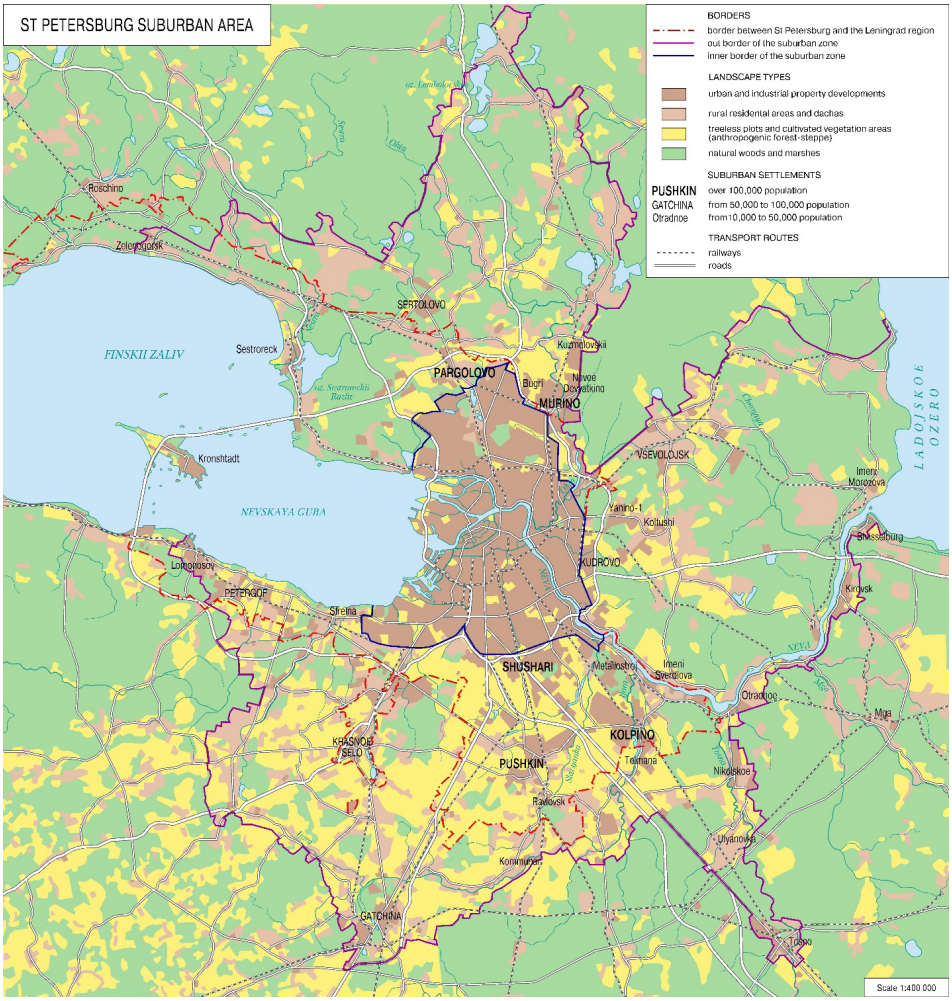

Fig. 8. The outer and interior boundaries of today's suburban area of St. Petersburg. Prepared by Tatiana Andreeva (2023)

The boundaries of the St. Petersburg suburban areas largely coincide with those of the First Belt of St. Petersburg agglomeration as proposed by Reznikov [28]. They are located the closest to each other to the north of St. Petersburg, especially in the unpopulated area, the farthest to the south, where transport and natural conditions significantly reduce the area of the suburban zone in comparison with those defined by Reznikov. Along the southern shore of the Gulf of Finland, the suburban zone stretches only to Oranienbaum-1 station, falling short of reaching the official border between St. Petersburg and the Leningrad region, let alone the town of Sosnovy Bor, which has never been considered a suburb of St. Petersburg [33]. By definition, a suburban zone cannot be divided into belts. Although some suburbs lie in the vicinity of St. Petersburg and others are located

at a more significant distance from the city, they all have more similarities than differences. Settlements that lack common characteristics cannot be classified as suburban.

Conclusions

The current administrative boundary of St. Petersburg, established legally in the mid-1990s and effectively in existence since the 1970s, serves as the 'organizing axis' of the suburban area but does not perform a barrier function. Most of the territories lying on either side of this border are completely homogeneous. Given that the administrative boundary has little effect on the spatial structure of society, attributing to it the role of a border that delineates the 'core' from the 'periphery', as commonly suggested, lacks justification.

The interior boundary of the suburban area follows the 40-minute transport isochrone, which in the conditions of today's St. Petersburg corresponds to about 20—22 km from the city centre assumed to be located in Kazanskaya Square. In the north and south of the city, this distance separates the centre from the outer boundary of the majority of multi-storey residential development; in the east, it slightly goes beyond its limits.

The outer boundary of the suburban zone is aligned with the two-hour isochrone, which lies today between 50 and 60 km away from the city centre. The areas of the territory located farthest from the city centre can no longer be considered part of the suburban area, which terminates approximately at the Zelenogorsk station on the northern shore of the Gulf of Finland and the Oranienbaum-1 station on its southern shore. The *de jure* territory of St. Petersburg along the northern shore of the Gulf stretches about 20 km westwards from the Zelenogorsk station and about 10 km from the Oranienbaum-1 station. However, the daily life of these areas is minimally, if at all, connected with St. Petersburg.

Moreover, the natural conditions of the outer boundary of the suburban zone are highly significant, as they contribute to the complex nature of this boundary. For instance, to the northeast of St. Petersburg, the suburban zone is divided by a sparsely populated forested area.

The landscapes in the suburban area, particularly to the south of St. Petersburg, exhibit characteristics that can be tentatively classified as 'anthropogenic forest-steppe'. These are vast, almost non-forested areas with primarily cultivated woody vegetation. During this time, it was primarily inhabited by Ingrian Finns, who were likely responsible for ploughing the most fertile lands in what is now the St. Petersburg suburban area. To the north of the city, the 'hallmark' of the suburban zone, alongside the 'anthropogenic forest-steppe', are the secondary small-leaved forests that have developed on abandoned agricultural lands and former noble estate parks. Determining the boundaries of the St. Petersburg suburban area appears to be crucial for assessing the potential and future trajectories of the city's spatial development. The boundaries of the agglomeration, variously drawn by different researchers and guideline documents, are based on the admin-

istrative boundaries of St. Petersburg and districts of the Leningrad Region. As noted earlier, the boundaries of St. Petersburg, and even those of the districts in the Leningrad region, have minimal influence on the spatial structure of society. A comprehensive approach to delineating the actual boundaries of the suburban area is crucial to mitigate further suburban sprawl and to pursue a balanced development policy that takes into account the interaction between society and the environment.

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References

1. Grant, J., Nelson, A., Forsyth, A., Thompson-Fawcett, M., Blais, P., Filion, P. 2013, The future of the suburbs. Suburbs in transition/The resettlement of America's suburbs/ Suburbs in global context: the challenges of continued growth and retrofitting/Suburban urbanity: re-envisioning indigenous settlement practices/Toward a new suburban America: will we catch the wave?/Optimistic and pessimistic perspectives on the evolution of the North American suburb/Response: Suburbs in transition, *Planning Theory and Practice*, vol. 14, № 3, p. 391—415, https://doi.org/10.1080/14649357.2013.808833

2. Jackson, K. T. 1985, *Crabgrass Frontier: The Suburbanization of the United States*, Oxford, Oxford University Press, 406 p.

3. Frost, L. 1998, *New Urban Frontier: Urbanisation and City Building in Australasia and the American West*, Sydney, 225 p.

4. McKee, D., McKee, Y. 2001, Edge Cities and the Viability of Metropolitan Economies: Contributions to Flexibility and External Linkages by New Urban Service Environments, *American Journal of Economics and Sociology*, vol. 60, № 1, p. 171—184, https://doi.org/10.1111/1536-7150.00059

5. Ness, H., Le Néchet, F., Terral, L. 2016, Changement de regard sur le périurbain, quelles marges de manoeuvre en matière de durabilité?, *Géographie, Économie, Société, Nouveaux regard sur le périurbain*, vol. 18, № 1, p. 15—33.

6. Slavova, M. 2019, Peri-urbanization in Bulgaria — potential for construction industry, *Real Estate Property & Business*, vol. III (I), p. 40—51.

7. Zasada, I., Fertner, C., Piorr, A., Sick Nielsen, T. 2011, Peri-urbanisation and multifunctional adaptation of agriculture around Copenhagen, *Geografisk Tidsskrift — Danish Journal of Geography*, vol. 111, № 1, p. 59—72, https://doi.org/10.1080/00167223.2011.10669522

8. Wandl, A., Magoni, M. 2017, Sustainable Planning of Peri-Urban Areas: Introduction to the Special Issue, *Planning Practice & Research*, vol. 32, № 1, p. 1—3, https://doi.org/10.1080/02697459.2017.1264191

9. Mortoja, G., Yigitcanlar, T. 2023, Why is determining peri-urban area boundaries critical for sustainable urban development?, *Journal of Environmental Planning and Management*, vol. 66, № 1, p. 67—96, https://doi.org/10.1080/09640568.2021.1978405

10. Martynov, V. L., Sazonova, I. E. 2023, Population change and the settlement system transformation in Poland, as revealed by the 2021 census, *Baltic Region*, vol. 15, № 2, p. 41—61, https://doi.org/10.5922/2079-8555-2023-2-3

11. Idczak, P., Mrozik, K. 2018, Periurbanisation: Evidence from Polish metropolitan areas, *Economic and Environmental Studies*, vol. 18, № 1, p. 173—192, https://doi.org/10.25167/ees.2018.45.11

12. Armstrong, W., McGee, T. G. 2007, *Theatres of Accumulation Studies in Asian and Latin American Urbanization*, Methuen: London and New York, 288 p.

13. Azorin, M. Yu. 2022, Review of the development of various urban planning concepts and models of urban agglomerations, *Baikal Research Journal*, vol. 13, № 3. EDN: KLPIUG (in Russ.).

14. McGee, T. G. 2021, The Emergence of Desakota Regions in Asia: Expanding a Hypothesis, in: Brenner, N. (ed.), *Implosions / Explosions*, p. 121—137, https://doi.org/10.1515/9783868598933-010

15. Breslavsky, A. S. 2012, Suburbs of Ulan-Ude and migration processes in the post-soviet Buryatia: the transformation of settlements and local communities, *The Bulletin of Irkutsk State University. Series Political Science and Religion Studies*, № 1, p. 92—99. EDN: PARRTV

16. Breslavsky, A. S. 2017, "Suburban Revolution": The regional case (Ulan-Ude), *Russian Peasant Studies*, vol. 2, № 1, p. 90—101, https://doi.org/10.22394/2500-1809-2017-2-1-90-101 (in Russ.).

17. Gnatyuk, G. A., Degteva, Z. F., Kuzin, V. Y. 2023, More on formation of the Yakutsk urban agglomeration, *Vestnik of North-Eastern Federal University Series "Earth Sciences"*, № 3, p. 65—72, https://doi.org/10.25587/SVFU.2023.31.3.008 (in Russ.).

18. Brade, I., Makhrova, A. G., Nefedova, T. G., Treyvish, A. I. 2013, Specific Features of Suburbanization in Moscow Agglomeration in the Post-Soviet Era, *Izvestiya Rossiiskoi Akademii Nauk. Seriya Geograficheskaya*, № 2, p. 19—29, https://doi.org/10.15356/0373-2444-2013-2-19-29

19. Degusarova, V. S., Martynov, V. L., Sazonova, I. E. 2018, Geodemography of the Saint Petersburg suburbs, *Baltic Region*, vol. 10, № 3, p. 19—40, https://doi.org/10.5922/2079-8555-2018-3-2

20. Shchepetkova, I. O. 2018, Dachas in the suburbs of Perm: history, territorial organization, and regional features, *Regional Research of Russia*, vol. 8, № 4, p. 386—394, https://doi.org/10.1134/S2079970518040093

21. Churakova, P. S. 2020, St. Petersburg Datcha's as a Cultural Frontier Zone, *Journal of Frontier Studies*, vol. 5, № 1, p. 83—94, https://doi.org/10.24411/2500-0225-2020-10005

22. Lachininskii, S. S., Sorokin, I. S., Maksimovich, N. V. 2023, Transformation of the residential system of the St. Petersburg agglomeration in the 2010—2022, *Geographical Bulletin*, № 3 (66), p. 41—53, https://doi.org/10.17072/2079-7877-2023-3-41-53 (in Russ.).

23. Olifir, D. I. 2022, Comparative Analysis of the Spatial Structures of the Moscow and St. Petersburg Agglomerations, *Prostranstvennaya Ekonomika = Spatial Economics*, vol. 18, № 1, p. 73—100, https://doi.org/10.14530/se.2022.1.073-100 (in Russ.).

24. Losin, L. A., Solodilov, V. V. 2019, The territorial structure of St. Petersburg city agglomeration, *Regional economics and territorial development*, vol. 1, № 13, p. 180—186. EDN: AKBDGP (in Russ.).

25. Kuznetsov, S. V., Losina, L. A. 2022, St. Petersburg agglomeration: stages of formation and development prospects, *SPb.: Institution of Science Institute for Regional Economic Studies of the Russian Academy of Sciences*, 219 p. EDN: UJKKCI (in Russ.).

26. Lapshina, E. M. 2023, Suburban real estate market of St. Petersburgand Leningrad Oblast during the COVID-19 pandemic, *Regional Studies*, № 1, p. 98—108, https://doi.org/10.5922/1994-5280-2023-1-8 (in Russ.).

27. Druzhinin, P. V. 2022, The growth of agglomerations and the efficiency of the economy, *Economy of the North-West: problems and prospects of development*, № 3 (70), p. 149—156, https://doi.org/10.52897/2411-4588-2022-3-149-156 (in Russ.).

28. Reznikov, I. L. 2017, Delimitation of the St. Petersburg urban agglomeration, *Vestnik of St. Petersburg University. Earth Sciences*, vol. 62, № 1, p. 89—103, https://doi.org/10.21638/11701/spbu07.2017.106 (in Russ.).

29. Martynov, V. L., Sazonova, I. E., 2020, Spatial Development of the Petrodvortsovy District of St. Petersburg: Primary Trends and Problems, in: Fedorov, G., Druzhinin, A., Golubeva, E., Subetto, D., Palmowski, T. (eds.), *Baltic Region — The Region of Cooperation*, Cham, Springer, p. 251—258, https://doi.org/10.1007/978-3-030-14519-4_28

30. Kryukova, O. V., Martynov, V. L., Sazonova, I. Y., Polyakova, S. D. 2016, Main spatial problems of St. Petersburg, *European Journal of Geography*, vol. 7, № 2, p. 85—95.

31. Okladnikova, E. A., Marova, O. A. 2014, Metaspace of suburban landscape of the northern environs of St. Petersburg in the late XIX — early XX centuries, *Research Result. Social Studies and Humanities*, vol. 1, № 2 (2), p. 52—62. EDN: TJBRC (in Russ.).

32. Zhogin, V. P. 2000, Development of the first nuclear charge RDS-41 (11D) for artillery projectile, *Combustion, Explosion, and Shock Waves*, vol. 36, № 6, p. 689—694. EDN: EQWMDZ

33. Konovalova, T. A. 2013, Mechanisms of economy efficiency functioning increase in Sosnovoborsk district of Leningrad's region, *Discussion*, № 3 (33), p. 31—40. EDN: PXPIGH (in Russ.).

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NATIONAL INNOVATION SYSTEMS: A COMPARATIVE STUDY OF THE BALTIC AND SOUTH CAUCASUS STATES

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This article aims to identify the determinants of the development of national innovation systems in the globalised world and to carry out a cluster analysis of innovation systems of the South Caucasus and Baltic States. To this end, an Innovation System Development Index (ISDI) comprising 46 indicators was developed. The authors employed the macro-clustering method, as well as aggregation and combination techniques for parameters and sub-indices. Additionally, complete-linkage and K-means methods were used to group the countries. Kalinsky-Kharabaz and Duda-Hart indices, as well as dendrograms, were found to be the most effective techniques for producing the novel classification proposed in this contribution. It was demonstrated using the former method that national innovation systems exhibit qualitatively different cluster characteristics and follow different development trends. According to the findings, Estonia ranks first on the index among the study countries with (ISDI = 0.77), while the South Caucasus states form two subgroups. Armenia (ISDI = 0.50) and Georgia (ISDI = 0.53) comprise a relatively developed subgroup, whereas Azerbaijan (ISDI = 0.44) constitutes a separate unit, delivering a less remarkable performance. The latter method revealed that the Baltic States form the most developed cluster group, with Estonia once again at the top of the index (ISDI = 0.85). The Baltic States and the South Caucasus states comprised two separate groups. Except for the patent activity sub-index, Estonia outperforms the other study countries on all sub-indices. Armenia and Georgia rank relatively high on the patent activity sub-index, whereas Azerbaijan performs well on the innovation activity and infrastructural development sub-indices. These findings would allow the South Caucasus countries to draw on the experience of the Baltic states in identifying challenges to the development of their national innovation systems. Overall, the study demonstrated the possibility of classifying the countries of the two post-Soviet regions based on the similarity of national innovation systems.

Keywords:
national innovation system, cluster analysis, innovation index, innovation activity, institutes, patent activity, innovation potential

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Introduction

Innovation is the cornerstone of success in the modern economy at firm, industry, regional, and national levels [1, p. 1]. According to Lundvall, "the concept of National Systems of Innovation can be regarded as a tool for analyzing economic development and economic growth" [2, p. 415]. The improvement of the national innovation system (NIS) ultimately contributes to the improvement of national competitiveness [3]. Freeman emphasised the importance of conducting research at the national level, especially for developing countries where issues of technological advancement are urgent [4]. Due to the assessment of innovation systems (IS), the interactions of system elements are presented [1; 5]. However, the research of the above-mentioned ISs at the national level faces comparability problems.[1] Hommen and Edquist noted that approaches to the research on NISs vary [6]. In one case, a large number of countries are included in the research, in the other case, the historical, geographical, and other features of the countries and the factor of the uniqueness of NISs are taken into account. Thus, the research on NISs requires a methodology that ensures comparability [7].

The evaluation and cluster analysis of the NISs of the Baltic and South Caucasus (SC) countries are of great interest, given the circumstances mentioned above. This analysis would reveal the development level and positioning of the NISs in these countries. We developed the Innovation System Development Index (ISDI), which will allow us to identify the current level of NIS. The ISDI is based on dozens of indicators, which, according to various researchers, economists, analysts, and experts, describe the NISs of countries. In this research, we considered the Baltic and South Caucasus regions. The ISDI was computed for each country (Estonia, Latvia, Lithuania, Armenia, Azerbaijan, and Georgia), facilitating comparisons of NIS development levels. This analysis aims to provide fresh insights into the dynamics and stability of innovation economy formation in these six countries. Through cluster analysis, the countries were divided into several groups, revealing recent trends in NIS development and their implications for innovation economies.

The remaining sections of the paper are structured as follows. Section 1 presents a literature review of approaches to NIS assessment and classification. Section 2 describes research methods. Peculiarities of NISs in post-Soviet countries and the Innovation System Development Index of six countries are presented in Section 3. Section 4 discusses the results, and the next section presents some conclusions on the topic.

Literature review

The concept of NIS

We conducted an extensive theoretical and methodological literature review, which guided the identification of future research directions. Among the early theorists of the concept, Patel and Pavitt emphasized the need to examine differ-

[1] Managing national innovation systems, 1999, Managing national innovation systems, 1999, OECD Publishing, Paris, URL: https://doi.org/10.1787/9789264189416-en (accessed 22.03.2023).

ences between countries' NIS [8]. Since the beginning of the 1990s, the basis for the development and evaluation of the NIS concept was laid. Nelson noted that it is preferable to study even a small number of comparable countries: implementation of best practices should be as systematic as possible and not in separate directions [9]. According to Makkonen, it is also necessary to consider the failed experiences of countries to avoid undesirable developments in the catch-up process [10]. For Lundvall, the best solution is the application of the concept through a combination of best practice and systemic feature discovery [11].

The levels of innovation systems can be set at discretion, depending on the problems faced by the research (geographical factors, sector specifics, etc.). According to Carlsson et al., the research on NIS effectiveness is one of the priority but little discussed topics. At the same time, the research on the NIS concept presents new challenges in terms of accurate system evaluation. This is natural, because NIS is, in fact, a dynamically developing organism [12]. The choice of research level depends on the size of the country. Acs and Varga pointed out: "For small states, the system might very well be larger than the nation" [13, p. 143].

The concept of NIS has not been free from criticism either. According to Świadek et al., NIS research at the macro level, although necessary, is mostly superficial and does not reflect system problems [14]. Kitanovic questioned the effectiveness of research based on the structural approach of NIS as the NIS of each country with an economy in transition develops in a certain unique historical way and with the introduction of various practices. Thus, the role of organisations and institutions that are part of the system may differ by country, and as a result, comparisons cannot be considered objective. For the author, the process-based approach was more acceptable, in which the main factor is the creation and diffusion of innovation [15]. Golichenko proposed a new methodological approach, in which two research methods, structural-objective and functional, were combined [16]. His approach was a mixture of the structural and process approaches mentioned by Kitanovich.

Despite some criticism, the NIS is still a widely accepted approach, because the political, cultural, institutional, and legal factors remain within the borders of the state [7; 17; 18]. Niosi believed that national and regional (subnational) innovation systems were the most acceptable approaches because the location of actors and elements of innovation processes (organisations and institutions, human capital, natural resources, etc.) is of great importance: "In different countries, they (NISs) may be composed by very dissimilar institutions (multiple equilibria), created under different historical circumstances" [19, p. 294—295]. During the thirty years of the development of the concept, various authors presented the factors of the formation and development of NIS (historical, cultural, socio-economic, institutional, geographical, sectoral, structural, and demographic) [3; 4; 9; 10; 17; 20—31]. Thus, despite some criticism, the NIS concept has garnered significant support since its inception, owing to its comprehensive nature and the continued relevance of examining innovation policy issues at the national level, despite globalization trends. Our literature review on the evaluation of innovation

systems across various levels led us to conclude that assessing innovation systems at the macro level, specifically at the national level, is one of the acceptable and commonly practised approaches.

The classification and assessment of NISs

The issue of classification and assessment of NIS has been relevant since the beginning of the 1990s [27]. Fagerberg and Srholec noted, that "there is currently no agreement in the literature on how innovation systems should be defined and studied empirically" [24, p. 1419]. OECD introduced two main methods of NIS research: "Macro-clustering sees the economy as a network of interlinked sectoral clusters. Functional analysis sees the economy as networks of institutions and maps knowledge interactions among and between them".[1] Evaluation or measurement of NIS is a rather complex process, given the large number of actors in the system and the multifaceted nature of the processes [3]. Guan and Chen noted: "Clearly, the innovation efficiency of a NIS is measured by the latter's ability to transform innovation input into output and generate profits" [32, p. 103].

In the literature, the issue of classification or cluster analysis of NIS has been consistently discussed. However, grouping based on country size or income alone is not an optimal solution. Park (1999, as cited in [28]) grouped countries into clusters based on R&D expenditure by organisation. Young-Geun Park and Guihyun Park considered the relationships between R&D structure and industrial structure. The authors concluded that the NIS performed as a system when R&D expenditure (GERD) was at least 2 % of GDP, which was possible due to the more active role of the private sector [28]. According to Balzat and Pyka, "...the cluster compositions may be used as a starting point for more targeted and more effective technology policy measures in the studied nations" [33, p. 169—170]. The authors wrote: "Hence, from the perspective of technology policymaking, international comparisons and especially classifications of national innovation systems are important extensions to the NIS concept. For, after all, these types of studies demonstrate where there is scope for mutual learning from experience. This in turn may raise the effectiveness of planned technology policy measures in the countries under analysis" [33, p. 169—170].

Balzat and Pyka carried out a classification of NISs of 18 OECD countries and identified structural similarities and dissimilarities of NISs. The dozens of indicators used in the research characterized several constituent elements of the NIS (financial conditions, innovative efforts, institutional framework conditions, the national knowledge base, international openness, and sectoral specifics). In particular, the authors emphasized the last element [33].

Belitz et al. compiled a composite NIS assessment index consisting of hard (innovation activity statistics) and soft (expert assessments) factors. The authors introduced seven key areas of NIS (education, R&D, finance, networking, reg-

[1] Managing national innovation systems, 1999, Managing national innovation systems, 1999, OECD Publishing, Paris, URL: https://doi.org/10.1787/9789264189416-en (accessed 22.03.2023).

ulation and competition, demand, production, and implementation). Nearly two dozen industrialized countries included in the research were then grouped into three groups according to the level of innovation development [34].

Castellacci and Natera noted that previous research had largely neglected the research on the dynamics of NISs and had focused on comparisons between NISs across countries. Thus, the observation of time series would only complement the comparisons between countries' NIS [35].

Bartels et al. considered various indicators of technological, economic, and human development of about five dozen developed and developing countries. In particular, for countries with limited natural resources, according to the authors, it is appropriate to focus on the creation of a healthy, competitive, and market environment [36]. Asikainen studied six small European countries (including Latvia and Estonia). In general, the main weakness of NIS in small countries is the scarcity of resources: the author introduced two ways of development (specialization and internationalization) and emphasized the role of the actors in the system [37]. Several factors are crucial for small countries, such as foreign direct investment, international cooperation, human and social capital, and flexible government policies (Roolaht, 2012, as cited in [38]). Alnafrah and Mouselli identified four main NIS factors (innovation, economic, infrastructural, and regulation), which can serve as a basis for comparing NIS [39]. Dworak et al. grouped NISs, made intergroup comparisons and concluded that the type of NIS predetermines the level of innovative development in EU countries [21].

Thus, in each work, an attempt was made to evaluate and classify the NIS of different groups of countries, which were combined in the context of different criteria. In addition to ensuring comparability, the application of the calculation methodology was important, particularly the selection of NIS factors and indicators.

NIS development in post-Soviet countries

Lundvall pointed out that the NIS approach is also applicable to developing countries [11]. Moreover, a portion of the NIS literature has been devoted to the research on NISs of developing and transition economies [17]. Sarewitz et al. tried to present the specifics of the assessment of NISs in developing countries, where large-scale investments are needed to fill the existing technology gap. The first steps are an accurate assessment of the system, the development of an appropriate strategy, and the definition of the possible functions of the individual actors [40].

In general, the development of post-industrial society, which is currently built on neoliberal policies and concepts of globalisation, is associated with the collapse of the USSR [41]. Makkonen tried to find out whether the NISs of the former socialist bloc countries were globally competitive, and what processes were taking place in the NISs of post-Soviet states. The author mentioned the poor level of research, assessment, and comparison of the NISs in post-Soviet states [3].

In the late 1990s, Radosevic considered it too early to accept the existence of NISs in Central and Eastern European countries due to industrial structural

changes and transition shocks [42]. Liu and White questioned whether the optimal solution for countries with economies in transition is to develop NIS systems similar to those of developed countries [7].

It is natural that the transition of the countries of the socialist bloc to the market economy directly affected their NISs. Based on the experience of the German Democratic Republic, Meske developed his three-phase model, according to which the change of scientific and technological systems takes place in the following sequence: the dissolution of the socialist system, the unification of the existing institutions and the integration of the latter into the emerging new systems. The author analysed the indicators of nearly two dozen countries and identified two directions of development in the countries of the socialist bloc: towards the EU NIS (Baltic countries) and towards the reconstruction of the Soviet-era NIS (e. g., Russia). The role of the geographical factor on the policy of the countries moving in the first direction was greater than the level of integration with the administrative institutions. The results indicated that the differences between the countries started to deepen from the beginning of the transition period [43]. After the demise of the USSR, development progressed rapidly in the Baltic States. With the development of NISs, influenced by a favourable scientific and technological environment, as well as liberal approaches, the Baltic countries have made great achievements [3]. Poghosyan linked the development of an effective NIS with getting rid of the Soviet heritage [38]. However, during the transition period, policies were taken at an inappropriate level in many countries, which led to greater negative consequences [23; 38].

Mussagulova noted: "Though vastly divergent in size, natural resource endowment and human capital, all 15 former Soviet states inherited Soviet institutions. The decision to shed those structures and ideas, however, has been anything but uniform across the post-Soviet region" [26, p. 87]. Observing the NISs of Estonia, Ukraine, and Kazakhstan, the author concluded that the countries retaining the Soviet institutional R&D model exhibited less developed NISs. Thus, the Soviet legacy significantly affects the innovation activities of states. Historically, the post-Soviet countries have similarities and differences, given their Soviet past and three decades of independence. Musagulova pointed out that experts had not researched the historical heritage of innovation activities of post-Soviet countries. The author considered several dimensions, from the participation of private and public sectors in innovation activity to the development of innovation links. According to the author, the Baltic countries have economic and geographical advantages compared to other post-Soviet countries. Post-Soviet countries have objective commonalities, although the author ignored the influence of the pre-Soviet historical factor [26].

There are various works devoted to the study of the NISs of the countries of the Baltic region. Klemeshev observed three groups of indicators (indicators of economic and research potential, indicators of dynamics of economic and research potential development, and indicators of economic and innovation potential of the states of the region). The author also mentioned about cooperation prospects in the Baltic region [44]. Mäkinen conducted comparisons of nine Baltic countries based on the data on innovation environment and innovation performance [45]. Merzhevich and Pribyshin made comparisons and revealed

differences among nine Baltic region countries in terms of national, regional and corporate levels. The authors also mentioned the so-called triple-helix model and its role in the development of NISs [46]. Azhinov and Lapshova researched the characteristics of scientific and technological development in 10 countries of the Baltic region (Germany, Sweden, Denmark, Norway, Finland, Poland, Estonia, Latvia, Lithuania and Russia). Based on quantitative data and cluster analysis, the authors identified certain patterns and grouped the countries into two major types: countries with a traditional market economy and post-socialist countries. Countries of the first type had a higher share of R&D expenditure in GDP (over 2 %) and also had a higher number of researchers per 1000 inhabitants. It should be noted that the second group of countries included Russia, Latvia, Lithuania, Estonia and Poland [47, p. 88].

Thus, our research included essential elements of the NIS approach, such as the selection of countries based on factors presented in the literature to ensure comparability, as well as the selection of indicators for the NIS assessment of transition economies.

Research methods

In the early 1990s, when the concept of NIS was in its early stages of development, the lack of data to reveal structural and technological changes in NIS was most evident [8]. We adopted a methodology based on previous research and optimal solutions presented for the evaluation of NISs. Fig. 1. Implementation of the above-mentioned methodology consists of several steps as follows:

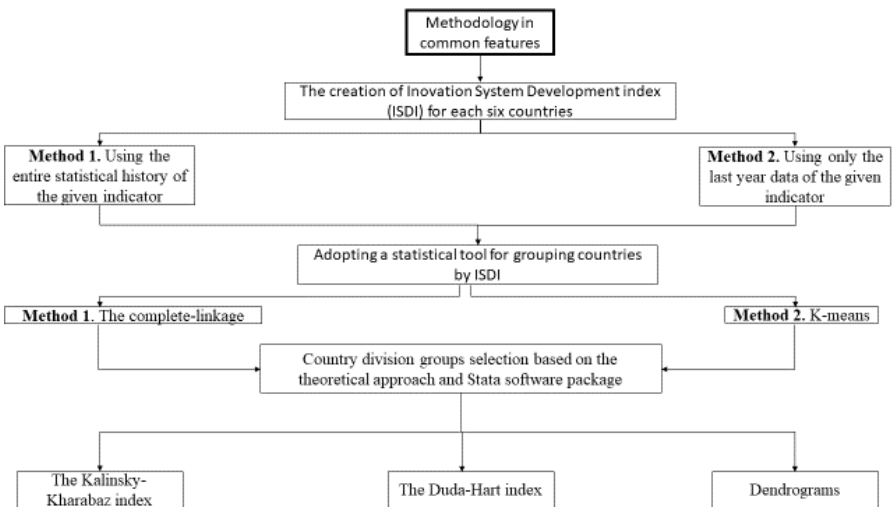

Fig. 1. Flowchart of the research methodology

1. The creation of an Innovation System Development index for each six countries. The index consists of seven subindexes characterizing seven areas (macro environment, human capital, institutions, infrastructure, science, patent activity and innovation activity). To calculate subindexes, we used 46 indicators and a number of statistical data for each of the six countries. The statistical data

included the 2007—2022 time period (see Appendix). The selection of indicators and areas was determined by the study of the experience of the evaluation of NISs in different periods. Thus, the approach adopted by us is based on both structural and functional methods, as presented by Golichenko [15].

NIS was presented through 46 indicators representing seven areas. In addition, the observation of data for about 10 years allowed us to identify most of the development trends of NISs. The data was also of two types (ordinary data and indexes). To calculate the subindexes, we have brought the statistical data of different dimensions to a normal form or one dimension. This process was different for ordinary data and indexes. In the process of index calculation, we used two methods. In the first case, the entire statistical history of the given indicator took part in the process of bringing the data to a single measurement. In the case of the second method, we used only the last year data.

After bringing the data to one dimension by two methods, we performed a calculation of subindexes, which represented the usual arithmetic mean of the normalized statistical data. The subindexes were used to perform a calculation of ISDI, which is the arithmetic mean of all the subindexes. It is worth focusing on the fact that the statistical data of the indicators used to calculate the ISDI relate to different time periods. The given situation reflects the existing objective reality.

Our approach builds on calculations from several global indices, such as the Global Innovation Index. These indices often rely on indicators derived from older statistics. We believe that including such indicators, even if they are not the most recent, is preferable to excluding them altogether. This approach ensures a more comprehensive general index, as the latest statistics may not yet be available. At the same time, there are indicators for which statistics are published with great delay. Moreover, we had two separate calculation methods. In one case, index indicators were brought to a single measurement using the most recent statistical data from each of them. In another case, the same measurability could be achieved by paying attention to the data history of the relevant indicators. As we noticed, the calculations were performed in both forms, and the corresponding results were obtained.

The advantage of our method is that a large number of indicators could be included in the calculation of the Index. In addition, a certain dynamism was given to the number, since in real life changes in indicators do not necessarily affect the relevant processes at the same time. In addition, it was possible not only to take into account the most recent data on indicators but also to define as a basis the widest possible period or history of changes in indicators.

2. Adoption of a statistical tool for grouping countries by ISDI. We used the ISDIs obtained as a result of the application of the two methods to perform a cluster analysis. To create clusters or groups of countries, we used the complete-linkage and K-means methods of cluster analysis. We applied each of the two methods to the statistical data obtained by the first and second methods. Thus, we proposed country division groups based on the theoretical approach, the Kalinsky-Kharabaz index, the Duda-Hart index, as well as dendrograms [47]. To increase the efficiency of the cluster analysis calculations, we also used the Stata software package. As a result of the analysis, we presented the division of the country groups (Fig. 2, Fig. 3).

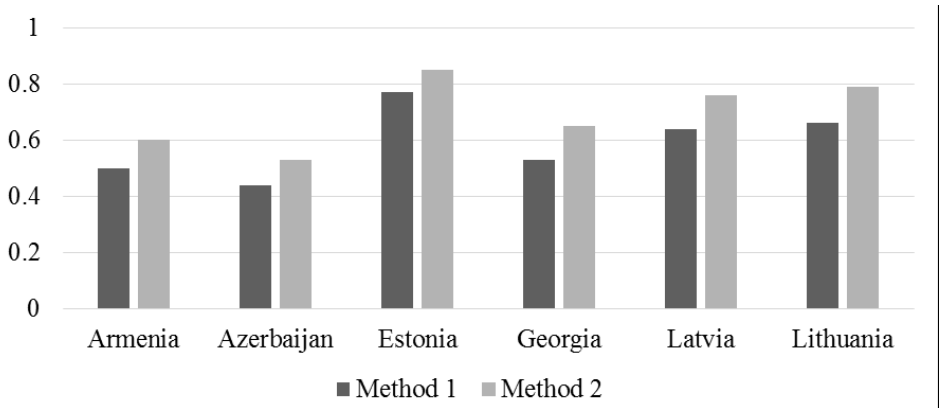

Fig. 2. Innovation System Development Index in Baltic and South Caucasus countries (score, 0—1)

Fig. 3. Baltic and South Caucasus countries groups based on the second method of calculation of the innovation system development index

Results

As shown in Table 1, in the case of the first method, Estonia is the absolute leader, as the latter's Macro Environment Index was 0.7. In Latvia and Lithuania, the subindex score is quite low. The situation is more complicated in the SC countries. In the case of the second method, the Baltic republics again were the leaders. The situation in the SC remained worrying (0.34 in Armenia, 0.23 in Azerbaijan and 0.53 in Georgia). The Baltic states have achieved quite high results in terms of human capital: the Human Capital Index of the countries was almost at the same level. In the SC, the results were above average, although the difference was significant. Scores decreased when the first method was considered. Azerbaijan was in the last place in the SC region, and Lithuania in the Baltic region. According to the second method, the Baltic countries are the leaders in terms of institutional development (INSI), followed by Georgia. Scores changed significantly when the calculations were made with the first method: Estonia (0.86) became the leading country. Georgia was the leader in the SC. In the case of the second method, Estonia (0.98) and Lithuania (0.87) were the leaders in terms of infrastructure. Azerbaijan (0.75) was the leader in the SC, which repeated the score of Latvia. Armenia was the last in terms of institutions. The picture was a little different in the case of the first method: Estonia was the absolute leader.

Table 1

Macro Environment, Human Capital, Institutions and Infrastructure sub-indexes in Baltic and South Caucasus countries (score, 0—1)

Country	MEI		HCI		INSI		INFI	
	M1	M2	M1	M2	M1	M2	M1	M2
Armenia	0.32	0.34	0.53	0.56	0.55	0.74	0.57	0.67
Azerbaijan	0.23	0.23	0.50	0.56	0.50	0.71	0.64	0.75
Estonia	0.70	0.77	0.76	0.87	0.86	0.88	0.90	0.98
Georgia	0.48	0.53	0.53	0.65	0.60	0.76	0.61	0.73
Latvia	0.57	0.67	0.71	0.79	0.73	0.82	0.67	0.75
Lithuania	0.57	0.76	0.74	0.81	0.76	0.81	0.79	0.87

Note: MEI — Macro Environment Index, HCI — Human Capital Index, INSI — Institutions Index, INFI — Infrastructure Index, M1 — first method, M2 — second method.

Source: own calculations based on data from World Bank (2016—2020; 2022), International Telecommunication Union (2022), The President and Fellows of Harvard College (2022), Bertelsmann Stiftung (2022), International Energy Agency (2022), The Global Competitiveness Report (2012—2019), Transparency International (2022), Fund for Peace (2022), Property Rights Alliance (2022), Reporters Without Borders (RSF) (2022), The Heritage Foundation (2022), Sustainable Development Solutions Network (2015—2022), International Labour Organization (2021), World Intellectual Property Organization (2022), World Health Organization (2020).[1]

[1] Doing Business 2016—2020, *The World Bank,* URL: https://archive.doingbusiness.org/en/reports/global-reports/doing-business-reports (accessed 22.04.2023) ; The world's richest source of ICT statistics and regulatory information, 2022, *ITU DataHub*, URL: https://datahub.itu.int/ (accessed 22.04.2023) ; Country & Product Complexity Rankings, 2022, *Growth Lab*, URL: https://atlas.cid.harvard.edu/rankings (accessed 18.03.2023) ; Atlas BTI, 2022, *Bertelsmann Stiftung*, URL: https://atlas.bti-project.org/ (accessed 16.04.2023) ; Electricity, 2022, *International Energy Agency*, URL: https://www.iea.org/fuels-and-technologies/electricity (accessed 19.06.2023) ; Global Risks Report 2012—2019, 2012—2019, *World Economic Forum*, URL: https://www.weforum.org/reports/ (accessed 15.03.2023) ; Corruption Perceptions index, 2022, *Transparency International*, URL: https://www.transparency.org/en/cpi/2021 (accessed 25.05.2023) ; Global Data, 2022, *Fragile State Sindex*, URL: https://fragilestatesindex.org/global-data/ (accessed 20.05.2023) ; International Property Rights Index 2022, *Property Rights Alliance*, URL: https://www.internationalpropertyrightsindex.org/countries (accessed 25.05.2023) ; Index, 2022, *Reporters Without Borders (RSF)*, URL: https://rsf.org/en/index?year = 2022 (accessed 01.06.2023) ; All Country Scores, 2022, *heritage.org,* URL: https://www.heritage.org/index/explore (accessed 18.05.2023) ; World Happiness Report 2015—2022, 2015—2022, *World Happiness Report*, URL: https://worldhappiness.report/archive/#partners (accessed 18.05.2023); ILOSTAT, 2021, *International Labor Organization*, URL: https://www.ilo.org/shinyapps/bulkexplorer44/ (accessed 05.04.2023) ; Key indicators, 2022, *WIPO*, URL: https://www3.wipo.int/ipstats/index.htm?tab=trademark (accessed 22.03.2023) ; Life expectancy at birth (years), *World Health organization*, https://www.who.int/data/gho/data/indicators/indicator-details/GHO/life-expectancy-at-birth-(years) (accessed 19.02.2023).

In the case of the second method, Estonia (0.91) was the leader in terms of the Science Index (Table 2). Scores of other countries were low. In the case of the first method, significant declines were recorded (the score was 0.74 in Estonia). Armenia (0.59) took the leading positions in the SC. In the case of both the first and second methods, the minimum scores of the Patent Activity Index were observed in Azerbaijan (0.13 and 0.19, respectively). In the case of the first method, an above-average score was observed only in Estonia (0.56). The scores of Armenia and Lithuania were the same (0.4). The application of the second method showed that Lithuania (0.73) was the leader. In the case of the second method, the Patent Activity Index was higher in Baltic countries. In the SC, Azerbaijan (0.71) was the leader, followed by Armenia (0.62) and Georgia (0.55). In case of the first method, the leaders in the regions did not change.

Table 2

Science, Patent activity and Innovation activity sub-indexes in Baltic and South Caucasus countries (score, 0—1)

Country	SI		PAI		IAI	
	M1	M2	M1	M2	M1	M2
Armenia	0.59	0.62	0.40	0.63	0.53	0.62
Azerbaijan	0.43	0.56	0.13	0.19	0.63	0.71
Estonia	0.74	0.91	0.56	0.63	0.85	0.93
Georgia	0.51	0.64	0.46	0.68	0.51	0.55
Latvia	0.49	0.69	0.51	0.70	0.76	0.88
Lithuania	0.60	0.76	0.40	0.73	0.72	0.76

Note: SI — Science Index, PAI — Patent Activity Index, IPI — Innovation Activity Index, M1 — first method, M2 — second method. Source: own calculations based on data from World Intellectual Property Organisation (2022), Scimago Lab (2022), World Bank (2022), United States Patent and Trademark Office (2020), The Global Competitiveness Report (2012—2019).[1]

Figure 2 illustrates ISDI on the basis of two methods. In the case of the first method, Estonia (0.77) was the leader. Lithuania, Latvia, Georgia and Armenia provided higher than average levels of the ISDI, and Azerbaijan (0.44) was a country with below than average results. In the case of the second method, Estonia (0.85) was the leader, followed by Lithuania and Latvia. The SC states fall behind the Baltic countries: Georgia was the leader, followed by Armenia and Azerbaijan.

[1] WIPO IP Statistics Data Center, 2022, *WIPO*, URL: https://www3.wipo.int/ipstats/index.htm?tab=trademark (accessed 22.03.2023) ; Country Comparison, 2022, *Scimago Lab*, URL: https://www.scimagojr.com/comparecountries.php (accessed 11.04.2023) ; Data Bank, 2022, *The World Bank*, URL: https://databank.worldbank.org/home (accessed 08.04.2023) ; Reports By Type of Patent Document and By Geographic Origin Patent Counts, Single Year Reports, 1992 to Present, *United States Patent and Trademark Office*, URL: https://www.uspto.gov/web/offices/ac/ido/oeip/taf/reports_stco.htm (accessed 01.03.2023) ; Global Risks Report 2012—2019, 2012—2019, *World Economic Forum*, URL: https://www.weforum.org/reports/ (accessed 15.03.2023).

The cluster analysis performed on the basis of the data obtained with the help of the second method showed that it was optimal to classify the countries into two groups as follows (see Fig. 3).

The first group consisted of the Baltic states and the second group comprised the SC states. As shown in Figure 4, the cluster analysis carried out with the results obtained by the first method suggested a different division.

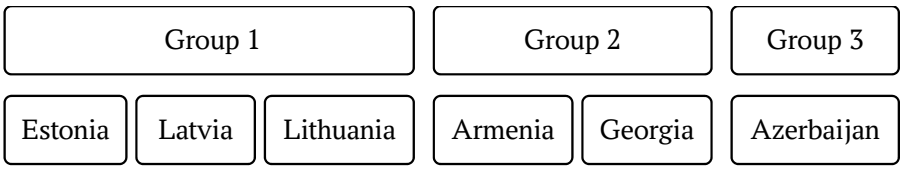

Fig. 4. Baltic and South Caucasus country groups based on the first method of calculation of the innovation system development index

The countries were divided into three groups. Baltic countries were included in the first group. Armenia and Georgia were in the second group. Azerbaijan was in a separate country group.

Discussion

In the research, we mentioned the Soviet legacy of the Baltic and South Caucasus states. It should be noted that this circumstance, as a historical and political factor, served only as a basis for the selection of the given group of countries and the evaluation of the NISs, among other factors. In other words, the influence of the Soviet past on the NISs of the countries was not studied. Instead, we sought to illustrate how countries in transition managed their more or less comparable Soviet legacy.

Based on previous studies, Alnafrah and Mouselli reported that Latvia's NIS was the least developed among the Baltic countries. Although significant reforms have been implemented in all three countries and a positive shift towards a knowledge-based economy has been recorded, there are certain challenges. In Estonia, there is a need for institutional and economic reforms, in Lithuania — the development of the labour market and high-tech industries, and in Latvia — the need to increase the innovation potential of SMEs. Although even these countries have national characteristics, the comparison of their NISs is appropriate [39].

There is a significant body of literature on the evaluation of the Baltic states' NISs. Based on data from the Baltic states, Alnafrah and Museli tried to identify the factors of the NIS that contribute to the expansion of entrepreneurial activity: as a result, infrastructural and economic factors were separated from the four factors forming the triple helix model [40].

Reforms of the Estonian NIS started in the late 1990s. In 1998, the Estonian Innovation Program was launched, followed by the National Development Program in 2000—2002. The "Knowledge-based Estonia" initiative was launched for 2014—2020, the main target of which was to improve productivity and the education system. Another project, the Entrepreneurship Growth Strategy, was aimed at promoting innovation and highly productive activities through specialization. The

Estonian Development Fund aims to promote start-up activity [26]. However, despite significant efforts, the level of scientific-educational and sectoral cooperation remains low. In addition, R&D expenditure is not directed to high-tech industries and is mostly allocated to a small number of organisations [39].

From the Soviet era to the EU membership and beyond, Latvia's economic structure has undergone tectonic shifts. However, only a small proportion of organisations belong to the high-tech industry. Besides, most of the up-to-date technology is imported [39]. "Latvia is considered the most vulnerable economy among the European Union economies in terms of the intensity of innovative companies" [39, p. 89—92]. As in Estonia, the links between research and the private sector are weak in Latvia. The pace of reforms in the education system is slow. To solve the mentioned problems, since 2007, a law has been in force in Latvia aimed at financing educational and research institutions [39].

The structural transformation of the Lithuanian economy took place at a faster pace. R&D expenditure continued to increase. It should be noted that the majority of innovation expenditure is allocated to the acquisition of equipment and technology imported from abroad. Back in 2009, reforms were implemented in the higher education system aimed at increasing the autonomy of educational institutions. Various policies and strategies aimed at improving innovation activity have been implemented in the country over the years (e. g., The Lithuanian *Innovation Strategy* for *2010—2020,* Valley Program, Lithuania 2030) [39].

In the case of the SC countries, the problems of modernising innovation systems and increasing their competitiveness are more complicated. First of all, it refers to the underdevelopment of the innovation infrastructures of the regional countries. This is primarily due to the inefficiency and incompleteness of the institutional and structural reforms implemented in the SC countries in the 1990s, which led to the disintegration of the high-tech industry potential, the degradation of human capital, science, and educational systems, and "brain drain". Our analysis confirmed that circumstance from the point of view that indicators of the development of the macro environment and human capital in SC countries are significantly inferior to the indicators characterizing the quality of the macro environment and human capital of the Baltic countries. Similar conclusions were obtained from the analysis of subindexes related to the quality of institutions regulating NISs and infrastructure development. The gap between the SC and the Baltic countries in terms of the integral indicators of the development of innovation policies and NISs is at a slightly lower level.

The United Nations Economic Commission for Europe [UNECE] presented the latest trends of NISs of the SC states as follows: Armenia tries to strengthen research-industry links, Azerbaijan emphasizes the diversification of the economy and Georgia tries to use its innovation potential as much as possible.[1]

Poghosyan emphasized the positive aspects of the Soviet legacy for Armenian NIS, such as the developed natural science research base, the presence of highly qualified specialists and the Armenian diaspora. Armenia was one of the technological hubs of the USSR. For that reason, a number of challenges arose in the post-Soviet period, as "...Armenia lost most of its R&D and production resources

[1] Sub-regional Innovation Policy Outlook 2020: Eastern Europe and the South Caucasus, 2021, *United Nations*, URL: https://unece.org/sites/default/files/2021-06/UNECE_Sub-regional_IPO_2020_Publication.pdf (accessed 30.04.2023).

precisely because it was very diversified for its small size" [38, p. 57]. The active public policy to support innovation began only at the beginning of the 21st century albeit with rather modest financial flows. However, a number of legislative regulations aimed at the formation of the NIS took place. Legislative reforms were aimed mainly at the promotion of high-tech exports and the development of knowledge-intensive industries, but research-industry links remained weak. For Armenia, as a country with such innovation potential, it is especially important to ensure strong links. Although various innovation platforms, free economic zones and science and technology parks have been established, the latter have not significantly improved the efficiency of the NIS. During the period of privatization, the role of foreign investment was not significant [38]. Although, in the 2010s, FDI in the high-tech sector, especially in the telecommunications sector, had a positive effect on the telecommunications revenue, as in Latvia and Lithuania [49]. Poghosyan noted: "However, the potential for FDI's contribution in Armenian IS is very small" [38, p. 65]. The author continued: "Overall, the efforts to build an efficient and knowledge-driven market economy in Armenia are still in their infancy" [38, p. 65]. In particular, Armenia's Digital Agenda 2030 is related to the issues of advanced electronic document management systems, security and digital workforce formation.[1]

The Georgia National Innovation Ecosystem (GENIE) project was launched in Georgia with international support, aimed at improving infrastructure and promoting innovation activity. Some successes in the development of the NIS have been recorded (favourable business and institutional environment, FDI attraction). Challenges are related to commercialization of innovation, strength of R&D network links, promotion of private sector investments, quality of education system, improvement of professional skills, promotion of innovation.[2] The research and innovation output is quite modest. Limitations of innovation potential are related to sectoral funding, bureaucracy, and lack of up-to-date technologies. The problems of Georgian NIS can be solved in three directions (financing, research activity, and NIS management).[3]

Despite the built science and technology parks, Azerbaijan's economy relies on the oil and gas industry and needs diversification. The improvement of the innovative environment in Azerbaijan should first of all be implemented by increasing the volume of financing, especially for SMEs. In addition, it is necessary to improve human capital, educational institutions-private sector links, as well as digitize the economy. In 2019, an innovation agency was launched in Azerbaijan to promote the commercialization of novelty and innovation activity. In addition, the Department of Innovative Development and E-government supports innovation in both the public and private sectors. However, there is a need to redistribute

[1] Sub-regional Innovation Policy Outlook 2020: Eastern Europe and the South Caucasus, 2021, *United Nations*, URL: https://unece.org/sites/default/files/2021-06/UNECE_Sub-regional_IPO_2020_Publication.pdf (accessed 30.04.2023).

[2] Ibid.

[3] Improving the effectiveness of Georgia's research and innovation system in Georgia through prioritisation, selectivity of funding and science-business links, 2018, *European Commission*, URL: https://www.zsi.at/object/publication/5126/attach/SS_Georgia_-_Final_Report__1_.pdf (accessed 30.04.2023).

the roles and functions of state institutions. The Innovation Ecosystem Map of Azerbaijan presents the projects and spheres of legislative regulation for effective innovation ecosystem formation.[1]

Our research proves that the NIS of any country is the totality of all relations and results of its previous historical, economic, technological and social development. A review of the literature, the Baltic states' policy of NIS restructurization since independence, and the results obtained in our research support this statement. The analysis of the NISs of the groups of post-Soviet countries with basically similar and comparable starting conditions (Baltic countries and SC countries) is of great interest.

Conclusions

The analysis and discussion in the article show that the processes of formation and transformation of the NISs of the clusters of the SC and Baltic countries, which are part of the community post-Soviet countries, testify to the existence of many problems related to the inefficiency of the existing institutional, infrastructural, and innovation policies. In particular, the problems refer to the weak links and low level of emergence of the components of the NISs.

The indexes calculated in the research indicate the fundamental differences in the development of the NISs of the SC and Baltic countries. The Baltic States were leaders in terms of ISDI. Estonia was an absolute leader in terms of all subindexes (except PAI). The biggest differences between the two regions were related to MEI. Armenia and Georgia were relatively close to the Baltic countries in terms of PAI. Azerbaijan surpassed Armenia and Georgia only in terms of INFI and IAI. If the NISs of the Baltic countries, are integrated into the economic area of the European Union and are essentially more oriented towards the classic schemes and mechanisms of innovation and technology creation, then the innovation systems of the SC countries are more oriented towards the mechanisms of technology import and technology imitation.

The analysis of the indicators and the literature on the transformation policy of the NISs of the Baltic countries shows that since the collapse of the Soviet Union and the achievement of independence, significant progress has been made in the innovation and technological potential. Basically, it is due to the effective institutional and structural reforms implemented in the Baltic countries, which moved along the path of NIS structural changes. The privatisation of state property and the formation of market infrastructure made it possible to form a stable macroeconomic environment in the Baltic countries in the late 1990s, which created important incentives for the development of scientific, innovation, and technological potential in these countries. The early membership in the European Union allowed the Baltic countries to integrate into the innovation networks and value chains of the developed European countries.

Nevertheless, our observations show that the existence of not-so-efficient and weak links of subsystems of NISs (science, educational-university institutions, state structures, business and corporate structures, financial systems, etc.) are still serious problems for the Baltic countries. Nevertheless, the NISs of the Baltic countries are developing in the context of the strategic approaches of the Euro-

[1] Sub-regional Innovation Policy Outlook 2020: Eastern Europe and the South Caucasus, 2021, *United Nations*, URL: https://unece.org/sites/default/files/2021-06/UNECE_Sub-regional_IPO_2020_Publication.pdf (accessed 30.04.2023).

pean countries, which allows them to continuously strengthen and develop both the innovation infrastructure and the innovation policy tools. Such development trends are also conditioned by the opportunities to integrate into common European innovation programs and to use centralised financing funds.

In general, we solved the problem set in the research. Taking into account the studied literature, the results of previous works, ensuring comparability was an important issue, which predetermined the selection of countries. However, it should be noted that this research can be considered a starting point in some sense. Apart from estimation and cluster analysis of NISs, the study and comparisons of separate system elements are also of great interest.

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Appendix

List of the used indicators

Macro Environment

1. GDP per capita, PPP (current international $), 2010—2020
2. Foreign direct investment, net inflows (% of GDP), 2010—2020
3. Manufactures imports (% of merchandise imports), 2010—2021
4. Trade (% of GDP), 2010—2020
5. Conflict intensity, score, 2022, 2010, 2012, 2014, 2016, 2018, 2020, 2022
6. Economic Complexity Index, score, 2010—2019

Infrastructure

7. Individuals using the Internet (% of population), 2010—2020
8. Mobile cellular subscriptions (per 100 people), 2010—2020
9.Electricity consumption per capita, MWh/capita, 2020, 2010—2020
10. Quality of Road Infrastructure 1—7 (best), 2019, 2013—2019

Institutions

11. Corruption perception index (score 0—100), 2012—2021
12. Human rights and rule of law (0 high- 10 low), 2010—2021
13. Property rights protection (score), 2016—2021
14. Ease of access to loans (score), 2016—2021
15. Protection of intellectual property rights (score), 2016—2021
16. Perception of IP protection (score), 2016—2021
17. Copyright protection (score), 2016—2021
18. Index of economic freedom (score), 2010—2022
19. World Press Freedom Index (0—100 score), 2013—2022
20. Freedom of expression, score (1—10), 2010, 2012, 2014, 2016, 2018, 2020, 2022
21. Ranking of happiness, score, 2015—2022
22. Ease of doing business score (DB17-20 methodology) 2016—2020

Science

23. Scientific and technical articles, per bln GDP PPP 2013—2021
24. Citable documents per 1 mln population, 2010—2021
25. Citations per document, number, 2010—2021
26. Citable documents H index 2013—2021
27. International collaboration, % 2010—2021
28. Open access, % 2010—2021
29. University industry research collaboration, score 2013—2021
30. Self-sites share, % 2010—2021

Patent Activity

31. Number of patent grants by WIPO per 1 mln population, 2010—2020

32. Number of patent applications by WIPO per 1 mln population, 2010—2020
33. Total trademark applications (direct and via the Madrid system) per 1 mln population, 2010—2020
34. Number or patent grants by USPTO, 2011—2020

Innovation Activity

35. Medium and high-tech manufacturing value added (% manufacturing value added), 2009—2019
36. High-technology exports (% of manufactured exports), 2010—2020
37. Knowledge intensive employment, 2015—2021
38. Buyer sophistication, 1–7 (best) (innovation capability commercialization), 2014—2019
39. Venture capial availability, 1–7 (best) 2014—2019
40. State of cluster development, 1–7 (best), 2014—2019

Human Capital

41. Life expectancy at brith, years, 2007—2019
42. Expenditure on education, % of GDP, 2007—2018
43. School enrollment, tertiary (% gross), 2007—2019
44. Output per worker (GDP constant 2010 US $), 2010—2021
45. Graduates in science and engineering, %, 2013—2021
46. Human flight and brain drain, (0 low- 10 high), 2010—2021

References

1. Schmutzler, J., Suarez, M., Tsvetkova, A., Faggian, A. 2017, Introduction. A context-specific two-way approach to the study of innovation systems in developing and transition countries, in: Tsvetkova, A., Schmutzler, J., Suarez, M., Faggian, A. (eds.), *Innovation in developing and transition countries*, p. 1—12, https://doi.org/10.4337/9781785369667.00008

2. Lundvall, B. Å. 1998, Why study national systems and national styles of innovation?, *Technology analysis & strategic management*, vol. 10, №4, p. 403—422, https://doi.org/10.1080/09537329808524324

3. Makkonen, T. 2014, National innovation system dynamics in East Central Europe, the Baltic countries, and Russia, in: Zhuplev, A., Liuhto, K. (eds.), *Geo-regional competitiveness in Central and Eastern Europe, the Baltic countries, and Russia*, IGI Global, p. 32—56, https://doi.org/10.4018/978-1-4666-6054-0.ch002

4. Freeman, C. 1995, The 'national system of innovation' in historical perspective, *Cambridge Journal of economics*, vol. 19, №1, p. 5—24, https://doi.org/10.1093/oxfordjournals.cje.a035309

5. Kravchenko, N. A. 2011, The problem of measuring and assessing national innovation systems, *Problems of Economic Transition*, vol. 53, №9, p. 61—73, https://doi.org/10.2753/PET1061-1991530904

6. Hommen, L., Edquist, C. 2009, Globalization and innovation policy, in: Edquist, C., Hommen, L. (eds.), *Small country innovation systems: globalization, change and policy in Asia and Europe*, Cheltenham, Edward Elgar Publishing, p. 442—484.

7. Liu, X., White, S. 2001, Comparing innovation systems: a framework and application to China's transitional context, *Research Policy*, vol. 30, №7, p. 1091—1114, https://doi.org/10.1016/S0048-7333(00)00132-3

8. Patel, P., Pavitt, K. 1994, National innovation systems: why they are important, and how they might be measured and compared, *Economics of Innovation and New Technology*, vol. 3, №1, p. 77—95, https://doi.org/10.1080/10438599400000004

9. Nelson, R. R. 1992, National innovation systems: a retrospective on a study, *Industrial and Corporate Change*, vol. 1, №2, p. 347—374, https://doi.org/10.1093/icc/1.2.347

10. Makkonen, T. 2015, National innovation system capabilities among leader and follower countries: widening gaps or global convergence?, *Innovation and Development*, vol. 5, № 1, p. 113—129, https://doi.org/10.1080/2157930X.2014.992818

11. Lundvall, B. Å. 2007, National innovation systems-analytical concept and development tool, *Industry and Innovation*, vol. 14, № 1, p. 95—119, https://doi.org/10.1080/13662710601130863

12. Carlsson, B., Jacobsson, S., Holmén, M., Rickne, A. 2002, Innovation systems: analytical and methodological issues, *Research Policy*, vol. 31, № 2, p. 233—245, https://doi.org/10.1016/S0048-7333(01)00138-X

13. Acs, Z. J., Varga, A. 2002, Geography, endogenous growth, and innovation, *International Regional Science Review*, vol. 25, № 1, p. 132—148, https://doi.org/10.1177/016001702762039484

14. Świadek, A., Dzikowski, P., Gorączkowska, J., Tomaszewski, M. 2022, The national innovation system in a catching-up country: empirical evidence based on micro data of a triple helix in Poland, *Oeconomia Copernicana*, vol. 13, № 2, p. 511—540, https://doi.org/10.24136/oc.2022.016

15. Kitanovic, J. 2007, The applicability of the concept of national innovation systems to transition economies, *Innovation*, vol. 9, № 1, p. 28—45, https://doi.org/10.5172/impp.2007.9.1.28

16. Golichenko, O. G. 2016, The national innovation system: from concept to research methodology, *Problems of Economic Transition*, vol. 58, № 5, p. 463—481, https://doi.org/10.1080/10611991.2016.1225452

17. Balzat, M., Hanusch, H. 2004, Recent trends in the research on national innovation systems, *Journal of evolutionary economics*, vol. 14, № 2, p. 197—210, https://doi.org/10.1007/s00191-004-0187-y

18. Pohulak-Żołędowska, E. 2016, Innovation in contemporary economies, *Oeconomia Copernicana*, vol. 7, № 3, p. 451—466, https://doi.org/10.12775/OeC.2016.026

19. Niosi, J. 2002, National systems of innovations are "x-efficient" (and x-effective): Why some are slow learners, *Research Policy*, vol. 31, № 2, p. 291—302, https://doi.org/10.1016/S0048-7333(01)00142-1

20. Andersen, E. S., Lundvall, B. Å. 1997, National innovation systems and the dynamics of the division of labor, in: Edquist, C. (ed.), *Systems of innovation: Technologies, institutions and organizations*, London, Pinter, p. 242—265.

21. Dworak, E., Grzelak, M. M., Roszko-Wójtowicz, E. 2022, Comparison of national innovation systems in the European Union countries, *Risks*, vol. 10, № 1, https://doi.org/10.3390/risks10010006

22. Edquist, C. 1997, Systems of innovation approaches–their emergence and chare acteristics, in: Edquist, C. (ed.), *Systems of innovation: Technologies, institutions and organizations*, London, Pinter, p. 1—35.

23. Egorov, I., Carayannis, E. G. 1999, Transforming the post-soviet research systems through incubating technological entrepreneurship, *The Journal of Technology Transfer*, vol. 24, № 2, p. 159—172, https://doi.org/10.1023/A:1007899204658

24. Fagerberg, J., Srholec, M. 2008, National innovation systems, capabilities and economic development, *Research policy*, vol. 37, № 9, p. 1417—1435, https://doi.org/10.1016/j.respol.2008.06.003

25. Freeman, C. 2002, Continental, national and sub-national innovation systems—complementarity and economic growth, *Research Policy*, vol. 31, № 2, p. 191—211, https://doi.org/10.1016/S0048-7333(01)00136-6

26. Mussagulova, A. 2021, Newly independent, path dependent: the impact of the Soviet past on innovation in post-Soviet states, Asia *Pacific Journal of Public Administration*, vol. 43, № 2, p. 87—105, https://doi.org/10.1080/23276665.2020.1805338

27. Niosi, J., Saviotti, P., Bellon, B., Crow, M. 1993, National systems of innovation: in search of a workable concept, *Technology in Society*, vol. 15, № 2, p. 207—227, https://doi.org/10.1016/0160-791X(93)90003-7

28. Park, Y., Park, G. 2003, When does a national innovation system start to exhibit systemic behavior?, *Industry and Innovation*, vol. 10, № 4, p. 403—414, https://doi.org/10.1080/1366271032000163649

29. Quéré, M. 2004, National systems of innovation and national systems of corporate governance: a missing link?, *Economics of Innovation and New Technology*, vol. 13, № 1, p. 77—90, https://doi.org/10.1080/1043859042000156048

30. Sachs, J. D., Mellinger, A. D., Gallup, J. L. 2001, The geography of poverty and wealth, *Scientific American*, vol. 284, № 3, p. 70—75, https://doi.org/10.1038/scientificamerican0301-70

31. Vertova, G. 1998, Technological similarity in national styles of innovation in a historical perspective, *Technology Analysis & Strategic Management*, vol. 10, № 4, p. 437—449, https://doi.org/10.1080/09537329808524326

32. Guan, J., Chen, K. 2012, Modeling the relative efficiency of national innovation systems, *Research Policy*, vol. 41, № 1, p. 102—115, https://doi.org/10.1016/j.respol.2011.07.001

33. Balzat, M., Pyka, A. 2006, Mapping national innovation systems in the OECD area, *International Journal of Technology and Globalisation*, vol. 2, № 1-2, p. 158—176, https://doi.org/10.1504/IJTG.2006.009132

34. Belitz, H., Clemens, M., von Hirschhausen, C., Schmidt-Ehmcke, J., Werwatz, A., Zloczysti, P. 2011, *An indicator for national systems of innovation: Methodology and application to 17 industrialized countries*, In: DIW Berlin Discussion Paper, № 1129, p. 1—35.

35. Castellacci, F., Natera, J. M. 2013, The dynamics of national innovation systems: a panel cointegration analysis of the coevolution between innovative capability and absorptive capacity, *Research Policy*, vol. 42, № 3, p. 579—594, https://doi.org/10.1016/j.respol.2012.10.006

36. Bartels, F. L., Voss, H., Lederer, S., Bachtrog, C. 2012, Determinants of national innovation systems: policy implications for developing countries, *Innovation*, vol. 14, № 1, p. 2—18, https://doi.org/10.5172/impp.2012.14.1.2

37. Asikainen, A. L. 2016, Small country strategies in complementing national innovation systems, *International Journal of Business Innovation and Research*, vol. 10, № 2-3, p. 246—266, https://doi.org/10.1504/IJBIR.2016.074828

38. Poghosyan, T. 2017, The state of the national innovation system of Armenia, in: Tsvetkova, A., Schmutzler, J., Suarez, M., Faggian, A. (eds.), *Innovation in developing and transition countries*, p. 49—67, https://doi.org/10.4337/9781785369667.00011

39. Alnafrah, I., Mouselli, S. 2020, The role of national Innovation systems in entrepreneurship activities at Baltic state countries, *Journal of the Knowledge Economy*, vol. 11, № 1, p. 84—102, https://doi.org/10.1007/s13132-018-0537-x

40. Sarewitz, D., Bozeman, B., Feinson, S., Foladori, G., Gaughan, M., Gupta, A., Sampat, B., Zachary, G. 2003, Knowledge flows and knowledge collectives: understanding the role of science and technology policies in development, *Synthesis report on the findings of a project for the Global Inclusion Program of the Rockefeller Foundation*, vol. 1&2, New York, Center for Science, Policy and Outcomes, Columbia University.

41. Scerri, M. 2014, Modes of innovation and the national systems of innovation of the BRICS economies, *STI Policy Review*, vol. 5, № 2, p. 20—42, https://doi.org/10.22675/STIPR.2014.5.2.020

42. Radosevic, S. 1999, Transformation of science and technology systems into systems of innovation in central and eastern Europe: the emerging patterns and determinants, *Structural Change and Economic Dynamics*, vol. 10, № 3-4, p. 277—320, https://doi.org/10.1016/S0954-349X(99)00016-8

43. Meske, W. 2000, Changes in the innovation system in economies in transition: basic patterns, sectoral and national particularities, *Science and Public Policy*, vol. 27, № 4, p. 253—264, https://doi.org/10.3152/147154300781781887

44. Klemeshev, A. 2011, A comparative assessment of the innovation potential of the Baltic Sea region countries, *Baltic Region,* vol. 8, № 2, p. 43—48, https://doi.org/10.5922/2079-8555-2011-2-5

45. Mäkinen, H. 2012, The innovative process in the Baltic Sea region, *Baltic Region,* vol. 13, № 3, p. 55—65, https://doi.org/10.5922/2079-8555-2012-3-5

46. Mezhevich, N., Pribyshin, T. 2012. Innovative economy in the Baltic Sea region. *Baltic Region*, vol. 13, № 3, p. 44—54, https://doi.org/10.5922/2079-8555-2012-3-4

47. Azhinov, D. G., Lapshova, T. E. 2023, A typology of the Baltic Region states according to excellence in science and technology, *Baltic Region*, vol. 15, № 1, p. 78—95, https://doi.org/10.5922/2079-8555-2023-1-5

48. Caliński, T., Harabasz, J. 1974, A dendrite method for cluster analysis, *Communications in Statistics-theory and Methods*, vol. 3, № 1, p. 1—27, https://doi.org/10.1080/03610927408827101

49. Margaryan, A., Terzyan, H., Grigoryan, E. 2020, Telecommunications sector of Armenia and Baltic countries: the impact of foreign direct investment attraction. *Economic Annals-XXI*, vol. 185, № 9-10, p. 99—107, https://doi.org/https://doi.org/10.21003/ea.V185-10

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POPULATION REPLACEMENT IN LATVIA: CURRENT STATE AND PROSPECTS

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This article analyses fertility rate trends in Latvia over a medium-term period of 53 years, from 1970 to 2022, aiming to predict the immediate prospects for population replacement. The novelty of this interdisciplinary research, which encompasses demography, mathematics, economics and sociology, lies in applying mathematical analysis to the study of socio-demographic processes, which has not been attempted before by Latvian or international researchers. Moreover, this study is the first to draw on the theory of economic cycles to identify demographic cycles and their phases in Latvia and predict the near-term birth rate in Latvia. Furthermore, analysing comparative data from 2004 and 2022 sociological surveys cast light on the principal cause of Latvia's declining fertility rate. This shift is due to changes in societal values, where the family and children no longer hold a central place, which is particularly true of women in Latvia. Consumerism-driven value changes have ceased to be a sine qua non of achieving their life goals and ambitions. Facilitating an increase in the fertility rate would require considering Latvian society's values and pursuing socioeconomic policies that comprise both internal measures, such as increasing residents' financial security, and external initiatives, including neighbourliness promotion. Latvia's fertility rates will continue to decline for several more years until the trough of the following demographic cycle is reached, which will be lower than that of the previous cycle. There will be an upturn within the linear downward trend in birth rates – but even this anticipated rise will not reach the earlier peak. Thus, as the findings of the study suggest, the projected increase in Latvia's total fertility rate to 1.77 children per woman, as envisioned by the FAMILY — LATVIA — 2030 (2050) Population Reproduction Strategy, is practically unattainable by 2027.

Keywords:
population reproduction, total fertility rate (TFR), mathematical analysis, demographic cycles, economic cycles, value changes, Latvia

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Introduction

The starting point for this study was the presentation of the "FAMILY — LATVIA — 2030 (2050) Population Reproduction Strategy" on November 9, 2022.[1] Since the presentation of the Strategy, its priorities and forecasts have been widely discussed in the Latvian mass media,[2] Latvian academic researchers have devoted considerable attention to issues of population reproduction in Latvia [1; 2] both before and after the presentation of the Strategy. Furthermore, studies documenting and analyzing current trends in declining fertility both globally and in post-Soviet countries have been published[3] [3—5]. They confirm the impact of similar external and internal factors on this problem: the influence of urbanization [6], increased life expectancy, uncertainty and instability of socioeconomic processes,[4] high levels of women's employment in the economy, qualitative changes in their reproductive attitudes in modern society (later marriage, increasing age of first-time mothers, increasing proportion of children out of wedlock, constant increase in child costs in market conditions, etc.).[5] This indicates the fact that the decline in fertility is not exclusively a Latvian problem; both the scientific community [7; 8] and the governments of many countries[6] are concerned about it.

The Strategy envisages achieving a fertility rate of 1.77 children on average per woman by 2027 with an intermediate indicator of 1.72 in 2024, a base indicator of 1.61 in 2018 and a real indicator of 1.57 in 2021. In turn, in 2022 the fertility rate in Latvia was 1.47.[7] Against the backdrop of real indicators, achieving the

[1] Tautas ataudzes stratēģija ĢIMENE — LATVIJA — 2030 (2050), 2022, *Pārresoru koordinācijas centrs*, URL: https://www.pkc.gov.lv/sites/default/files/inline-files/TAS_Plans%2009.11%20projekts.pdf (accessed 20.09.2023).

[2] Zitmane, M., Lāma, E. 2023, "Wake up and think of the children!": The ambivalent relationship betweenmotherhood, femininity and anti-vaccination, In: *The New Communication Revolution, Uniwersytet Jagiellonski — Instytut Dziennikarstwa, Mediow i Komunikacji Spolecznej*, p. 245—270, URL: https://www.researchgate.net/publication/372852271_Wake_up_and_think_of_the_children_The_ambivalent_relationship_between_motherhood_femininity_and_anti-vaccination (accessed 20.09.2023).

[3] *What Does the Global Decline of the Fertility Rate Look Like?* 2022, World Economic Forum, URL: https://www.weforum.org/agenda/2022/06/global-decline-of-fertility-rates-visualised/ (accessed 20.09.2023).

[4] Kearney, M. S., Levine, Ph. B. 2022, The causes and consequences of declining US fertility, *ASPEN Economic Strategy Group*, URL: https://www.economicstrategygroup.org/publication/kearney_levine/ (accessed 20.09.2023).

[5] McDonald, P. 2020, A projection of Australia's future fertility rates, *Centre for Population of Australian Government*, URL: https://population.gov.au/sites/population.gov.au/files/2021-09/2020_mcdonald_fertility_projections.pdf (accessed 20.09.2023).

[6] Mubila, M. 2012, Briefing Note 4: Africa's demographic trends, *Briefing Notes for AfDB's Long-Term Strategy*, URL: https://www.afdb.org/fileadmin/uploads/afdb/Documents/Policy-Documents/FINAL%20Briefing%20Note%204%20Africas%20Demographic%20Trends.pdf (accessed 20.09.2023).

[7] Dzimstības koeficienti (summārais, atražošanās, vispārīgais, vecumkoeficienti) 1965—2022, 2023, *Latvijas Republikas Centrālā statistikas pārvalde*, URL: https://data.stat.gov.lv/pxweb/lv/OSP_PUB/START__POP__ID__IDK/IDK010/table/tableViewLayout1/ (accessed 20.09.2023).

goal put forward in the Strategy in relation to the fertility rate — 1.77 by 2027 — seems unlikely. Zane Varpiņa, a Latvian researcher in the field of demography, and associate professor at the Riga School of Economics has called this Strategy "a letter to Santa Claus".[1]

The article aims to study the medium-term fertility trend in Latvia in terms of the total fertility rate (TFR). It is a demographic coefficient that estimates the average number of children a woman would bear over her lifetime if she were to experience the age-specific fertility rates observed in a given year throughout her reproductive years, typically defined as ages 15 to 50.[2] The study is carried out using mathematical analysis tools [9—11], namely, differentiating the TFR function within the medium-term period 1970—2022 (53 years), which includes two decades of the so-called Soviet era, as well as the period of Latvian independence after the demise of the Soviet Union. The main research question that the authors aim to address and scientifically substantiate in this study is: is it possible to increase the Total Fertility Rate (TFR) in Latvia in the near future, as envisioned in the "Population Reproduction Strategy"?

Literature review on fertility trends in the modern world

In countries and regions of the modern world, many researchers [5; 7] and international organisations[3] analysed changes in the fertility rate determined by social, economic, cultural and medical factors. In general, the results of studying fertility trends in the modern world can be grouped into several blocks that describe the most current phenomena and processes in the field of fertility analysis.

The first important and generally recognised process is the decline in the birth rate in almost all developed countries. Furthermore, in less developed countries, fertility trends are also directed towards decreasing fertility [4; 7]. For example, in Saudi Arabia, which in 1970 held the record for fertility with a rate of 7.28 children per woman, the TFR was only 2.24 in 2020.[4]

In Europe, the already low birth rate is also falling [6]. According to Eurostat, in 2010, six European countries were still at the threshold of sub-regenerative fertility (on average 2.1 children per woman) — France, Iceland, Ireland, Nor-

[1] Eiropa izmirst — ko darīt, lai Latvijā dzimtu vairāk bērnu? Pēta "Aizliegtais paņēmiens", 2023, *Latvijas Sabiedriskie Mediji Lsm.lv*, URL: https://www.lsm.lv/raksts/zinas/zinu-analize/eiropa-izmirst-ko-darit-lai-latvija-dzimtu-vairak-bernu-peta-aizliegtais-panemiens.a491783/ (accessed 20.09.2023).

[2] Dzimušo skaits un dzimstības koeficienti, 2023, *Latvijas oficiālā statistika*, URL: https://stat.gov.lv/lv/statistikas-temas/iedzivotaji/dzimstiba/238-dzimuso-skaits-un-dzimstibas-koeficienti (accessed 20.09.2023).

[3] What Does the Global Decline of the Fertility Rate Look Like? 2022, *World Economic Forum*, URL: https://www.weforum.org/agenda/2022/06/global-decline-of-fertility-rates-visualised/ (accessed 20.09.2023).

[4] World Population Prospects 2022, 2022, *United Nations*, URL: https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/wpp2022_summary_of_results.pdf (accessed 20.09.2023).

way, Sweden, and Great Britain. Ten years later, in 2020, no other European country reached the target of 2 children per woman.[1] In terms of the fertility rate, Latvia ranks in the middle among European countries.[2] The main factors contributing to a sustainable decline in the birth rate are considered to be an increase in the number of women pursuing careers and higher education, leading to delayed childbearing and fewer children over a woman's lifetime. Additionally, people tend to marry later, which shortens the reproductive window and often results in fewer children. Improved access to and use of contraception allows individuals to control the timing and number of children they have, significantly reducing unintended pregnancies. Finally, evolving societal values and norms increasingly support smaller families, gender equality, and women's autonomy in making reproductive choices. These factors collectively contribute to a decline in birth rates across various societies[3] [4; 5].

Another significant phenomenon associated with fertility trends, and widely discussed in scientific and analytical publications worldwide, is the demographic transition that many countries are undergoing. The demographic transition, which entails changes in fertility and mortality rates due to economic development and sociocultural changes, has several stages. One of these stages is marked by a decline in the birth rate, occurring after the mortality rate has decreased. The decline in fertility below the level of simple generation replacement in economically developed countries occurred in the second half of the 20th century. At the end of the 1980s, the concept of the second demographic transition was introduced [12], which is still widely used in the analysis of demographic development [13—15]. Coleman, analysing ethnic and social transformations as a result of immigration in several European countries and the United States, proposed using the concept of the third demographic transition as a theoretical basis for explaining new sociodemographic trends [16]. In his article, Latvian demographer Zvidrins (1979) analysed the changes in the birth rate in Latvia over the past 100 years. The results of his study showed that the decline in fertility, as well as in neighbouring Estonia, began earlier than in other parts of the then-Russian Empire [1]. As for modern Latvia, Krumins and Krisjane concluded that the sociodemographic situation in Latvian society is characterized by the features of the second demographic transition (decrease in fertility to a level close or even below sub-regenerative fertility, approximately 2.1 children on average per woman) with a focus towards the third demographic transition (a further decrease in fertility to the lowest rates) [14].

[1] Population and Demography, Total fertility rate (tps00199), 2023, *Eurostat*, URL: https://ec.europa.eu/eurostat/web/population-demography/demography-population-stock-balance/database (accessed 20.09.2023).

[2] Tautas ataudzes stratēģija ĢIMENE — LATVIJA — 2030 (2050), 2022, *Pārresoru koordinācijas centrs*, URL: https://www.pkc.gov.lv/sites/default/files/inline-files/TAS_Plans%2009.11%20projekts.pdf (accessed 20.09.2023).

[3] Unāma, E., Jansone, M. 2022, Krustpunktā Lielā intervija: demogrāfe Zane Vārpiņa, *Latvijas Radio1*, URL: https://lr1.lsm.lv/lv/raksts/krustpunkta/krustpunkta-liela-intervija-demografe-zane-varpina.a167968/ (accessed 21.09.2023).

The third significant phenomenon, extensively discussed in numerous scientific publications and analytical reports by international organisations, concerns the factors influencing fertility trends in the modern world. This study identifies five primary groups of factors commonly mentioned and analysed in the global scientific and analytical literature on fertility:

(1) public policy — measures taken by the government to increase the fertility rate: maternity benefits, maternity leave, free education and medical care for children, etc. [4; 17];

(2) economic factors — economic stability and opportunities for parents, influencing the decision to have children [6; 13];

(3) cultural and value factors — cultural and religious norms that influence fertility (in some societies, great importance is attached to a large family, in others, women strive for a professional career and postpone the birth of children,[1] society's values regarding family planning are changing) [3; 7; 8];

(4) technological progress in medicine — medical technologies (for example, artificial insemination and embryo preservation methods) affecting fertility [5; 6];

(5) level of education — women's education is usually associated with later motherhood and lower fertility since educated women usually strive for career and personal development [3; 6; 7].

The results of many studies show that the synergy of several determining factors leads to changes in fertility trends, and single-factor explanations are unlikely to be useful for explaining complex sociodemographic processes influenced by various structural and ideological changes [5; 15]. Furthermore, the general background against which a particular factor determining fertility operates is also important, since not a single political instrument will work if the country does not have a favourable socioeconomic and political environment for its implementation [17].

The authors' review and analysis of publications on modern fertility trends revealed that these analyses are predominantly descriptive. For example, a description of the demographic situation in Latvia notes: "The TFR shows the most favourable situation in the 1980s and the lowest level of reproduction population in the second half of the 1990s" [18].

Such a descriptive approach to analysing fertility trends is, firstly, rather superficial, lacking detailed analysis and understanding of fertility dynamics. Secondly, it fails to provide a scientific basis to answer the primary question of this study: the potential for increasing the Total Fertility Rate (TFR) in Latvia in the near future. The authors of the article hope to fill this methodological gap in demographic research with the help of a mathematical analysis of the fertility trend in Latvia for the medium-term period 1970—2022 (53 years).

[1] McDonald, P. 2020, A projection of Australia's future fertility rates, *Centre for Population of Australian Government*, URL: https://population.gov.au/sites/population.gov.au/files/2021-09/2020_mcdonald_fertility_projections.pdf (accessed 20.09.2023).

Research methodology

Mathematical analysis plays a key role in demographic and social studies [9], making it possible to predict sociodemographic trends, such as fertility rates, based on the analysis of past data. This is an approach based on technical analysis of indicators, without an in-depth study of the factors influencing them [19; 20], although the impact of such factors on fertility is also considered in the framework of this study.

The information base for this study is publicly available data from official Latvian statistics on the Total Fertility Rate (TFR) for the period 1970—2022.[1]

To develop a mathematical model of the nonlinear process of changes in the fertility level in Latvia over several decades, that is, to compile a formula for the TFR function using several dozen points using the least squares method (LSM), the authors realize data approximation using a polynomial of the nth degree [10]:

$$f(x) = a_0 + a_1 x + a_2 x^2 + \ldots + a_n x^n, \quad (1)$$

where f(x) is the approximating function; a_0, a_1, a_2, ..., a_n — coefficients that need to be calculated (a_0 is the value of the free term, which indicates the value of y at $x = 0$, — thus, this is the initial fertility rate at the beginning of the period under study); x is the independent variable.

The main idea of approximation is to find the function that best fits the observed data [11], in our case, the data on TFR in Latvia over the last half-century. This allows us to replace a complex function with a simpler one and simplify mathematical calculations and data analysis.

It is important to note that approximation methods like least squares fitting always entail some degree of error in the results [11; 21]. The quality of the approximation can be assessed using the coefficient of determination R^2, which ranges from 0 to 1 and shows the proportion of variation of the studied indicator explained by the equation obtained as a result of the approximation, that is, it shows how well the approximating function corresponds to the original data. The statistical significance of the R^2 coefficient can be confirmed by testing the null hypothesis of Fisher's F-statistics [21].

To achieve the goal of this study, the authors chose the polynomial type of interpolation as the most suitable approximation method. It consists in constructing a function that passes through given points and approximates the function values at intermediate points [10]. The resulting polynomial function consists of the sum of various terms, each of which is the multiplication of the degree of the variable x and the coefficient before this degree (1). For a more accurate assessment and interpretation of the polynomial function, the authors use its additional

[1] Dzimstības koeficienti (summārais, atražošanās, vispārīgais, vecumkoeficienti) 1965—2022, 2023, *Latvijas Republikas Centrālā statistikas pārvalde*, URL: https://data.stat.gov.lv/pxweb/lv/OSP_PUB/START__POP__ID__IDK/IDK010/table/tableViewLayout1/ (accessed 20.09.2023).

analysis. The authors differentiate the function [9], calculating and analysing its derivatives at each point corresponding to each year of the period under study, and visualise the graph of the medium-term (53 years) fertility trend in Latvia.

It should be noted that methodologically, even a simple comparison of TFR indicators between specific years can give an idea of how the fertility level has changed over different periods of time. Differentiation of a function, in turn, provides a more general and continuous way of analyzing changes of an indicator (in this case, TFR) throughout the entire time period being studied, not limited only to specific years. Analysis of derivatives allows us to identify more subtle trends and periods of change that may not be noticeable with a simple comparison of indicators [9; 10]. Differentiating a function (defining and analyzing its derivatives) can also help identify precise points in a trend change, such as the exact year in which fertility rates began to fall or rise.

For a polynomial function (1), where n is the degree of the polynomial, and a_0, a_1, a_2, …, a_n are the coefficients, the derivative at each point x will be calculated by differentiating each term separately using the rule for differentiating the degree function x^n [11]:

$$dy/dx(x^n) = nx^{n-1}. \quad (2)$$

Thus, for a polynomial degree function, the derivative is calculated in general form as follows [11]:

$$dy/dx = 0 + 1 \cdot a_1 \cdot x^{1-1} + 2 \cdot a_2 \cdot x^{2-1} + \ldots + n \cdot a_n \cdot x^{n-1} \quad (3)$$

or for short:

$$dy/dx = a_1 + 2a_2x + \ldots + na_nx^{n-1}. \quad (4)$$

Since a polynomial function can have different slopes in different parts of its graph, calculating its derivative at each point x allows finding out how quickly the value of the function changes depending on the change in the variable x. The smaller the absolute value of the derivative, the slower the fertility rate changes in the vicinity of a particular year within the time period studied [10; 11]. By analysing the absolute values of the derivatives, we can determine in which years fertility decreased or increased more rapidly, and in which years it changed more gradually. If the derivative is negative at a certain point, this means that as the value of x increases in the vicinity of that point, the value of the function decreases. Graphically, this means that the function has a decreasing slope in the vicinity of the corresponding point. On the contrary, if the derivative is positive at a particular point, then as the value of x increases in the vicinity of this point, the value of the function also increases (the function has an increasing slope) in the vicinity of this point [10; 11].

Results of the study

To conduct a mathematical analysis of the fertility trend in Latvia over the medium-term period from 1970 to 2022 (spanning 53 years), the authors will begin by presenting the initial statistics for the Total Fertility Rate (TFR) from 1970 to 2022 (Table 1).

Table 1

Total fertility rate (TFR), the average number of children per woman, 1970—2022, Latvia

Year	TFR	Year	TFR	Year	TFR	Year	TFR
1970	2.01	1984	2.14	1998	1.12	2012	1.44
1971	2.03	1985	2.08	1999	1.18	2013	1.52
1972	2.05	1986	2.21	2000	1.25	2014	1.65
1973	1.96	1987	2.21	2001	1.22	2015	1.70
1974	1.99	1988	2.16	2002	1.25	2016	1.74
1975	1.96	1989	2.04	2003	1.32	2017	1.69
1976	1.93	1990	2.00	2004	1.29	2018	1.60
1977	1.88	1991	1.86	2005	1.39	2019	1.61
1978	1.86	1992	1.74	2006	1.46	2020	1.55
1979	1.86	1993	1.52	2007	1.54	2021	1.57
1980	1.88	1994	1.41	2008	1.58	2022	1.47
1981	1.88	1995	1.27	2009	1.46	—	—
1982	1.97	1996	1.18	2010	1.36	—	—
1983	2.12	1997	1.13	2011	1.33	—	—

Source: compiled according to official Latvian statistics.[1]

The data presented in Table 1 confirms the thesis that social processes do not evolve linearly. In the case of the Total Fertility Rate (TFR) in Latvia, there has been a consistent alternation between periods of increasing and decreasing fertility over the past half-century.

Following the methodology of this study, the data will be approximated, as a result of which the following mathematical model of the TFR changes in Latvia over the analyzed time period has been constructed:

$$y = 0{,}0097x^6 - 0{,}1751x^5 + 1{,}1776x^4 - 3{,}599x^3 + 4{,}8292x^2 - 2{,}393x + 2{,}2168, \quad (5)$$

where y is the value of the approximating function; x is the ordinal number of the year in 53 years (0 corresponds to 1970, 5.2 to 2022), reduced by 10 times to avoid linear growth of the derivative due to large values of the year serial number [11].

[1] Latvijas Republikas Centrālā statistikas pārvalde. 2023, IDK010. Dzimstības koeficienti (summārais, atražošanās, vispārīgais, vecumkoeficienti) 1965—2022, Statistikas datubāze, URL: https://data.stat.gov.lv/pxweb/lv/OSP_PUB/START__POP__ID__IDK/IDK010/table/tableViewLayout1/ (accessed 20.09.2023).

Thus, the approximating mathematical model of changes in fertility in Latvia over the past half century is a polynomial function of the sixth degree. This means that the relationship between the variables (in our case, between the TFR and the serial number of the year within the period 1970—2022) is complex and contains nonlinear effects [10]. The coefficient of determination R^2 is equal to 0.8463, this indicates a good quality of approximation: the proportion of variation over time in the total fertility rate explained by the resulting equation is almost 85 %. As stated in the methodological section of this study, the assessment of the statistical significance of the R^2 coefficient was performed by testing the null hypothesis of Fisher's F-statistics. The calculated value $F_{act} = 42.2$ at a 1 % significance level, which is larger than the critical value $F_{cr} = 4.3E\text{-}17$ (calculated in MS Excel according to official Latvian statistics). The null hypothesis about the inconsistency of the equation obtained as a result of approximation is rejected. This means that the coefficient of determination R^2 is statistically significant and can be used to assess the quality of the resulting mathematical model [21].

Based on the approximating mathematical model of changes in the TFR in Latvia over the last half century (5), the following main conclusion can be drawn, characterizing the nonlinear 'wave' essence of the process under study in the medium term: since polynomials have several extrema on the graph, then the medium-term fertility trend in Latvia has several local maxima and minima, which indicates the complex nature of the relationship between the variables. In practice, this means that the medium-term fertility trend in Latvia is not linear, that is, there have been and will be ups and downs in fertility, which in themselves do not say anything about the general direction of the trend — downward or upward. These fluctuations in the fertility level, repeated over time, resemble economic cycles, or cycles of economic activity [1] , and characterize only short-term cyclical changes that periodically replace each other: an increase in the fertility level is followed by a decrease, then an increase again, then a decrease again, etc. This happens regardless (by and large) of changes in political regimes, economic conditions, climate change and other factors, the influence of which on fertility indicators is superimposed on each other[2] and provides a result that does not go beyond the worldwide longer-term trend of declining fertility.

However, to more accurately assess the nature of the relationship between variables, it is necessary to construct a graph of this function. The graph makes it

[1] Economic cycles are fluctuations in economic activity, consisting of repeated economic downturns (recessions, depressions) and economic upturns. The cycles are periodic, but not regular. The duration and amplitude of the oscillations can vary greatly. In economic theory, several types of cycles are distinguished according to their duration: the Kitchin cycle — 3—4 years, the Juglar cycle — 7—11 years, the Kuznets cycle — 15—25 years, the Kondratiev cycle — 45—60 years [22].

[2] In a mathematical model of medium-term fertility trend, this overlapping influence of various socioeconomic and political factors on fertility rates is empirically explained by the fact that the strong influence of any term in a polynomial does not always mean that this term has the largest significance in the function; the values of coefficients and degrees in a polynomial function can mutually compensate each other [11].

possible to visually assess the shape of the dependence and highlight the features of the function — such as extrema and bends, as well as visually represent the general direction of the fertility trend in Latvia.

If we try to briefly characterize the fertility trend in Latvia over the last half century, shown in Figure 1, we can say that it is a smoothly decreasing wavy trend with periodic rises and falls in the fertility level, reflecting demographic cycles — similar to economic cycles. However, as mentioned in the methodological section of this article, to identify more subtle trends and periods of change that may not be discernible through a simple comparison of fertility indicators, it is necessary to differentiate the function obtained as a result of the approximation (Equation (5) and Fig. 1). This involves finding the derivative of the function at each point *x*, representing the ordinal number of the year within the entire 53-year period under study. These derivatives will also help the authors to identify the exact moments of trend change (not yet manifested in the TFR indicators), for example, the exact year when the trend began to turn in the opposite direction — from a decrease to an increase in the fertility rate or from an increase to a decrease.

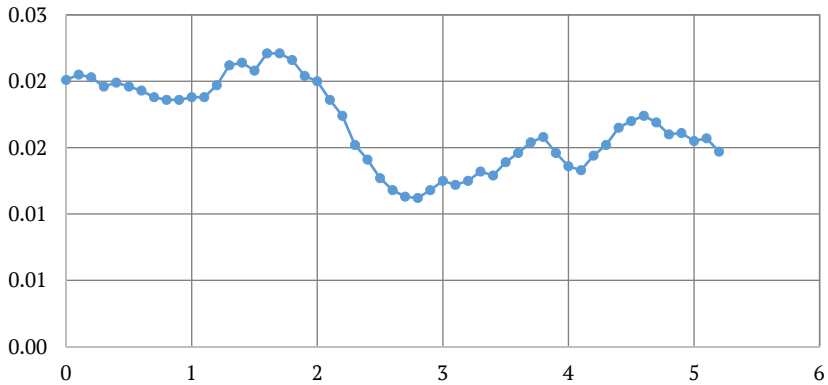

Fig. 1. Graph of changes in the total fertility rate (TFR),
the average number of children per woman, 1970—2022, Latvia

Note: the y-axis shows total fertility rates, and the x-axis shows years (1970 is the zero reference point, 1971 is 0.1, etc. up to 5.2 — 2022).

Source: created in MS Excel according to official Latvian statistics.

The general mathematical model for calculating derivatives of the polynomial degree function obtained as a result of data approximation within the period 1970—2022 is as follows:

$$dy/dx = 0{,}0582x^5 - 0{,}8755x^4 + 4{,}7104x^3 - 10{,}797x^2 + 9{,}6584x - 2{,}393, \quad (6)$$

where: dy/dx is the derivative for the argument x for the approximating function y (5); x is the ordinal number of the year in the 53-year period (0 corresponds to 1970, 5.2 to 2022).[1]

[1] Calculated based on (5) and the rule for differentiating the degree function x^n [11].

Table 2 shows changes in the TFR and the derivative of the fertility function in Latvia over the period 1970—2022, and also provides an empirical interpretation (in relation to fertility) of changes in the values of the derivative.

Table 2

Changes in the total fertility rate (TFR) and values of the derivative of the approximating function, 1970—2022, Latvia

Year	Fertility rate, TFR	Change in TFR compared to the previous year	Derivative* of the approximating fertility function	Percentage change** in the derivative compared to the previous year	Empirical interpretation (in relation to fertility) of change in the derivative
1970	2.01	—	–2.3930	—	Previous growth in fertility rates slowed down (in 1965 the TFR was 1.74)
1971	2.05	0.04	–1.5305	36.0	
1972	2.03	–0.02	–0.8569	44.0	
1973	1.96	–0.07	–0.3470	59.5	
1974	1.99	0.03	0.0225	106.5	The growth in fertility rates slowed down as much as possible and turned towards decline
1975	1.96	–0.03	0.2729	1112.9	
1976	1.93	–0.03	0.4236	55.2	Fertility rates continued to fall but at a slower rate
1977	1.88	–0.05	0.4926	16.3	
1978	1.86	–0.02	0.4958	0.6	The decline in fertility rates stopped and turned towards growth
1979	1.86	0.00	0.4478	–9.7	
1980	1.88	0.02	0.3615	–19.3	Fertility rates continued to rise but at a slower rate
1981	1.88	0.00	0.2483	–31.3	
1982	1.97	0.09	0.1184	–52.3	
1983	2.12	0.15	–0.0197	–116.6	Fertility growth stopped and a downward trend emerged
1984	2.14	0.02	–0.1583	–703.6	
1985	2.08	–0.06	–0.2913	–84.0	Fertility rates continued to fall but this decline was slowing down (the short-term rise in TFR in 1986—1987 did not change the general trend of declining fertility)
1986	2.21	0.13	–0.4135	–41.9	
1987	2.21	0.00	–0.5208	–25.9	
1988	2.16	–0.05	–0.6100	–17.1	
1989	2.04	–0.12	–0.6791	–11.3	
1990	2.00	–0.04	–0.7266	–7.0	
1991	1.86	–0.14	–0.7520	–3.5	
1992	1.74	–0.12	–0.7554	–0.5	
1993	1.52	–0.22	–0.7375	2.4	
1994	1.41	–0.11	–0.6997	5.1	
1995	1.27	–0.14	–0.6439	8.0	
1996	1.18	–0.09	–0.5722	11.1	
1997	1.13	–0.05	–0.4872	14.9	
1998	1.12	–0.01	–0.3920	19.5	
1999	1.18	0.06	–0.2894	26.2	
2000	1.25	0.07	–0.1829	36.8	

The end of Table 2

Year	Fertility rate, TFR	Change in TFR compared to the previous year	Derivative* of the approximating fertility function	Percentage change** in the derivative compared to the previous year	Empirical interpretation (in relation to fertility) of change in the derivative
2001	1.22	–0.03	–0.0757	58.6	The decline in fertility rates stopped and there was a growing trend in fertility
2002	1.25	0.03	0.0288	138.0	
2003	1.32	0.07	0.1274	342.4	Fertility rates continued to rise But this growth was slowing down (the short-term decrease in the TFR in 2009—2010 did not change the general trend of growth in the fertility level)
2004	1.29	–0.03	0.2170	70.3	
2005	1.39	0.10	0.2946	35.8	
2006	1.46	0.07	0.3575	21.4	
2007	1.54	0.08	0.4034	12.8	
2008	1.58	0.04	0.4305	6.7	
2009	1.46	–0.12	0.4373	1.6	
2010	1.36	–0.10	0.4230	–3.3	
2011	1.33	–0.03	0.3873	–8.4	
2012	1.44	0.11	0.3306	–14.6	
2013	1.52	0.08	0.2542	–23.1	
2014	1.65	0.13	0. 1602	–37.0	
2015	1.70	0.05	0.0514	–67.9	
2016	1.74	0.04	–0.0682	–232.7	Growth stalled at 1965 levels and fertility rates began to decline
2017	1.69	–0.05	–0.1937	–184.0	The decline in fertility rates continued but at a slower rate
2018	1.60	–0.09	–0.3189	–64.6	
2019	1.61	0.01	–0.4367	–36.9	
2020	1.55	–0.06	–0.5385	–23.3	
2021	1.57	0.02	–0.6145	–14.1	
2022	1.47	–0.10	–0.6535	–6.3	

Note: * Derivatives were calculated in MS Excel strictly according to (5), taking into account three or four decimals, respectively.

** Calculation of the percentage change in the derivatives compared to the previous year is necessary to consider the relative differences between the derivatives and reduce the effect of a purely mathematical relationship between the values of the approximating function and its derivatives caused by a change in the variable x [11].

Source: calculated and compiled according to official Latvian statistics.

The data in Table 2 (as well as the graph in Figure 1) show the cyclical nature of the medium-term fertility trend in Latvia, which, however, has a generally decreasing slope: from a TFR equal to 2.01 children on average per woman in 1970 to 1.47 in 2022. Furthermore, during the medium-term analysis of fertility trends in Latvia, there were frequent periods of apparent contradiction. For instance, there were times when the Total Fertility Rate (TFR) increased while the deriva-

tive of the approximating function (indicating the rate of change) was negative, such as in 1970—1971 and 1983—1984. Conversely, there were periods when the TFR decreased while the derivative of the function was positive, as observed in 2003—2004 and 2009—2010.

Such situations serve as a compelling example of the importance of not only examining the primary indicators under study, such as the Total Fertility Rate (TFR), but also considering the derivatives of the approximating function. This approach provides a more comprehensive understanding of fertility changes within the broader trend framework (Fig. 2). For example, the negative derivative of the approximating function in 1970—1971 with a simultaneous actual increase in the TFR, indicated that the previous growth was slowing down (in 1965, the TFR was 1.74[1]), and the negative derivative observed during 1983—1984, alongside an increase in the TFR, indicated that growth had halted and a downward trend in fertility rates had begun. The positive derivative of the approximating function in 2003—2004, along with an actual decrease in the Total Fertility Rate (TFR), indicated that while fertility was declining, the rate of decline was slowing down. Additionally, the temporary dip in TFR during 2009—2010, likely influenced by the shock from the 2008 global financial crisis, did not change the overall trend of fertility growth observed from 2003 to 2015.

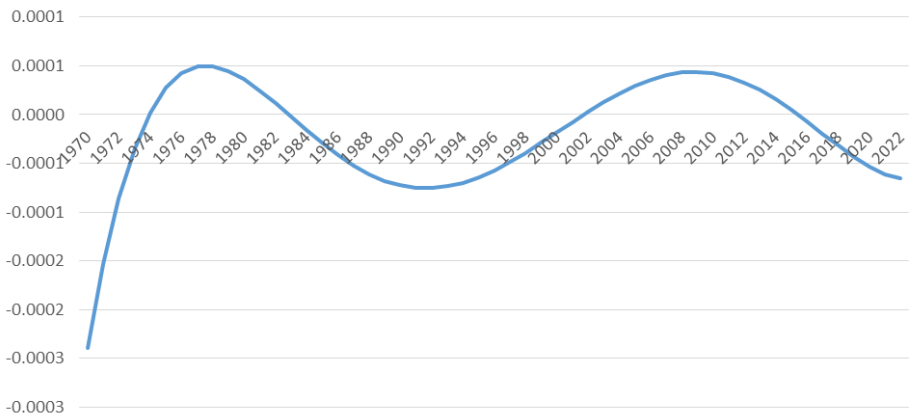

Fig. 2. Curve of the derivative of the approximating function of the total fertility rate (TFR), 1970—2022, Latvia

Source: created in MS Excel according to official Latvian statistics.

The curve of the derivative of the approximating function of the TFR in Latvia, shown in Figure 2, confirms a fairly uniform cyclical nature of the fertility

[1] Dzimstības koeficienti (summārais, atražošanās, vispārīgais, vecumkoeficienti) 1965—2022, 2023, *Latvijas Republikas Centrālā statistikas pārvalde,* URL: https://data.stat.gov.lv/pxweb/lv/OSP_PUB/START__POP__ID__IDK/IDK010/table/tableViewLayout1/ (accessed 20.09.2023).

trend, with periodic slowdowns and accelerations in the growth and decline of the fertility level, at least since 1973, that is, relatively long before the change in socioeconomic formation and political status of Latvia in the early 1990s.

In Table 3, the authors delineated different phases of demographic cycles in Latvia, drawing an analogy with economic cycles: growth (expansion), peak or boom, decline (recession), and bottom (depression). This framework was used to predict the trajectory of the fertility trend in Latvia in the near future, addressing the central research question posed in the article's introduction: can Latvia increase its fertility levels as envisioned in the "Population Reproduction Strategy"?

Table 3

Identification of different phases of demographic cycles by analogy with economic cycles, 1970—2022, Latvia

Time interval	Empirical interpretation of changes in derivatives in the context of TFR	Duration of the phases of demographic cycles	Designation of phases of demographic cycles
1970—1973	Previous growth in fertility rates slowed down (TFR was 1.74 in 1965*, 1.96 in 1973)	4 years that fell within the study period 1970—2022	Growth (expansion)
1974—1975	The growth of the fertility level first slowed down and then turned began to decrease (TFR was 1.99—1.96)	2 years	Peak or boom
1976—1977	The decline in fertility continued but at a slower rate (TFR was 1.93—1.88)	2 years	Decline (recession)
1978—1979	The decline in fertility stopped and shifted towards growth (TFR was 1.86—1.86)	2 years	Bottom (depression)
Next demographic cycle			
1980—1982	The increase in fertility continued but slowed down (TFR was 1.88—1.97)	3 years	Growth (expansion)
1983—1984	Fertility growth stopped and there was a trend towards a decrease in the fertility rate (TFR was 2.12—2.14)	2 years	Peak or boom
1985—2000	The decline in fertility continued but slowed down (TFR was 2.08—1.25); in 1986—1987 there was a short-term rise in the TFR as a result of M. Gorbachev's anti-alcohol campaign (TFR was 2.21)	16 years	Decline (recession)

The end of Table 3

Time interval	Empirical interpretation of changes in derivatives in the context of TFR	Duration of the phases of demographic cycles	Designation of phases of demographic cycles
2001—2002	The decline in fertility stopped and an upward trend emerged (TFR was 1.22—1.25)	2 years	Bottom (depression)
Next demographic cycle			
2003—2015	The increase in fertility continued but at a slower rate (TFR was 1.32—1.70); in 2009-2010 there was a sharp short-term decline in the TFR as a result of the shock from the global financial crisis of 2008 (the TFR was 1.46—1.36)	13 years	Growth (expansion)
2016	Growth plateaued at the 1965 fertility level (1.74) and there was a downward trend in fertility rates	1 year	Peak or boom
2017—2022	The decline in fertility continued but at a slower pace (TFR was 1.69—1.47)	6 years	Decline (recession)

Note: * The authors do not have data on the fertility rates in Latvia before 1965.

Source: compiled according to Table 2.

Discussion of the results

The main findings of the authors' mathematical analysis of Latvia's medium-term fertility trend spanning from 1970 to 2022 (53 years), as succinctly presented in Table 3, reveal empirically substantiated demographic cycles that bear striking resemblance to economic cycles. These cycles, well-established in macroeconomic theory [22] and even interrelated with them [23], depict a historical process in demography as a sequence of phases analogous to economic cycles. Moreover, these demographic cycles reflect cyclical fluctuations in per capita consumption, mirroring cycles of real wages or income.[1]

Based on the results of the mathematical analysis, it is projected that the decline in fertility levels in Latvia will persist for several more years until reaching the bottom of the next demographic cycle. This nadir is anticipated to be lower than the previous one, specifically below 1.22—1.25 children on average per

[1] Nefyodov, S. A. 2001, About the theory of demographic cycles, *Abstracts of the report at the CER meeting,* URL: http://www.hist.msu.ru/Labs/Ecohist/OB8/nefedov.htm (accessed 20.09.2023) (in Russ.).

woman. Subsequently, a reversal towards increasing fertility levels is expected as part of a long-term trend of declining fertility. However, this growth trajectory is forecasted to fall short of reaching the previous peak, which was around 1.74 children on average per woman. Therefore, the anticipated rise in fertility in Latvia to reach 1.77 children per woman by 2027, as envisioned by the authors of this study, is deemed unachievable under any realistically feasible socioeconomic and political conditions in the country.

The primary reason cited by the authors of this study for the impossibility of increasing the fertility level in Latvia in the near future is attributed to societal value changes. These shifts are extensively researched, documented, and discussed by sociologists and demographers not only in Latvia but also in Lithuania and other countries. In Soviet times, a couple with two children was considered the ideal family model: both having many children and being childless were rare [1]. This ensured the achievement of a fertility level close to 2.0. Currently, as shown by the data of comparative sociological "Study of factors contributing to marriage, fertility and positive child-parent relationships" conducted by the University of Latvia in 2004 (n = 1970 people) and in 2022 (n = 2297 people), "the family still has value (family safety, health of loved ones), but the child is no longer the only and necessary means of realizing one's life ambitions, no longer at the center of the individual value system"[1] (Table 4).

Table 4

Hierarchies of values, 2004 (n = 1970 people) and 2022 (n = 2297 people), Latvia

Value	Rank in the hierarchy of values		Value
	2004	2022	
Family safety (safety of loved ones)	1	1	Family safety (safety of loved ones)
Health (no physical or mental illness)	2	2	Health (no physical or mental illness)
Children and family (as an intrinsic value)	3	3	Peace in the whole world(without wars and conflicts)
Inner harmony	4	4	Freedom (freedom of action and thought)
Mature love	5	5	Inner harmony
Self-esteem	6	6	Self-esteem
Sincere friendship	7	7	Honesty

[1] Pirsko, L., Sebre, S., Upmane, A. 2022, Laulību, dzimstības un pozitīvu bērnu-vecāku attiecību veicinošo faktoru izpēte: 2022. gada un 2004. gada pētījumu rezultātu salīdzinājums, Pārskats par pētījumu, *Valsts Pārresoru koordinācijas centrs*, URL: https://pkc.gov.lv/sites/default/files/inline-files/Laulibu_dzimstibas_pozitivu_attiecibu_izpete_2022_1.pdf (accessed 20.09.2023).

The end of Table 4

Value	Rank in the hierarchy of values		Value
	2004	2022	
Freedom (freedom of action and thought)	8	8	Intelligence
Intelligence	9	9	Country safety (protecting my people from enemies)
Honesty	10	10	Sincere friendship
Peace in the whole world(without wars and conflicts)	11	11	Mature love
…			
Country safety (protecting my people from enemies)	24	22	Children and family (as an intrinsic value)

Source: Pirsko, L., Sebre, S., Upmane, A. 2022, Laulību, dzimstības un pozitīvu bērnu-vecāku attiecību veicinošo faktoru izpēte: 2022. gada un 2004. gada pētījumu rezultātu salīdzinājums, Pārskats par pētījumu, *Valsts Pārresoru koordinācijas centrs*, URL: https://pkc.gov.lv/sites/default/files/inline-files/Laulibu_dzimstibas_pozitivu_attiecibu_izpete_2022_1.pdf (accessed 20.09.2023).

The authors reviewing the results of the aforementioned study commented on the significant decline in the perceived importance of children and family within the hierarchy of values in Latvian society. They stated, "This result suggests that as the perceived value of children and family diminishes, it is likely that individuals will exert less effort to pursue these values. Consequently, there may be reduced willingness among people to start a family and have children".[1] The current tendency among young people not to put in extra effort (in the next case — to work) is also evidenced by the results of an international survey conducted by the recruiting company Randstad Deutschland of 35,000 young people aged 18 to 24 years. 58 % of respondents said they would leave their job if it interfered with their enjoyment of life, and 38 % had already done this at least once. Many personnel managers in Western (and not only Western) companies complain that young people do not want to take responsibility, do not want to work a full 5 days a week and avoid 'overtime' in every possible way.[2]

[1] Pirsko, L., Sebre, S., Upmane, A. 2022, Laulību, dzimstības un pozitīvu bērnu-vecāku attiecību veicinošo faktoru izpēte: 2022. gada un 2004. gada pētījumu rezultātu salīdzinājums, Pārskats par pētījumu, *Valsts Pārresoru koordinācijas centrs*, URL: https://pkc.gov.lv/sites/default/files/inline-files/Laulibu_dzimstibas_pozitivu_attiecibu_izpete_2022_1.pdf (accessed 20.09.2023).

[2] Baumeyster, A. 2023, Don't work! Be lazy and enjoy life!, YouTube, URL: https://www.youtube.com/watch?v=kGTmltmPYeQ (accessed 20.09.2023) (in Russ.).

In turn, for researchers of the phenomenon of female childlessness in Lithuania, the results of a comparative survey of women of two generations led to the conclusion that "the subjectively perceived reasons for not having children revealed different ways of experiencing childlessness among two generations of women. <...> The differences between women of two generations are especially noticeable in terms of voluntary childlessness. Older women do not openly say that they themselves decided to remain childless, although they admit that they never really wanted children. On the contrary, young women are not afraid to say that they have decided to remain childless and are enjoying it" [3, p. 19—20]. These results fully correspond with the results of sociological surveys in Latvia.

Thus, "value choice largely determines the pace and direction of the evolution of modern society" [24, p. 247], which is also true for its demographic development. "Previously, it was believed that it was achievements in the economy that were the decisive factor in improving people's lives, achieving social dynamism and the success of countries in international cooperation" [25, p. 427]. Much later, the "programming role of culture" [24, p. 246] was recognized as "a way of transmitting accumulated sociohistorical experience (suprabiological programs of human life) in the organisation of social life, in its changes and the generation of various types of society... In order for the type of society to change and a new one to arise, there must be a change in the cultural code, mutation of ideological universals, and then technical and economic development and competition with other societies will determine the future fate of the new type of social organisation" [25, p. 428—429].

According to the authors, this understanding of changes in demographic development in modern society needs some adjustment. Latvian society belongs to an individualistic and 'feminine' type of culture (caring for others, law-abiding, striving for personal success) [26] with a dominant mentality of rural (peasant) conservatism, for which active adaptation to the realities of a market economy (behavioural attitudes towards profit, competition) is alien [27]. In the conditions of socioeconomic instability in the functioning of Latvian society, men of working age and women of fertile age, when making decisions about having children, pay the main attention to the level of personal and family well-being, state attention to their health and financial safety of the family and often recognize this attention as insufficient, accepting the decision to migrate to other EU countries. This is especially typical for the age cohort from 15 to 44 years [28, p. 92].

To solve the problems of population reproduction, the Latvian government needs to focus its main efforts on achieving sustainable well-being of the population of the country and its regions, taking care of people's health, the innovative development of local agricultural, as well as medium- and high-tech industrial production [29], good neighbourly and mutually beneficial socioeconomic relations with countries bordering Latvia.

Conclusions

The results of this study showed that in Latvia there are empirically based demographic cycles that are similar to and related to economic cycles. But unlike economic cycles, which are well developed in macroeconomic theory, the concept of demographic cycles is practically not used either in Latvia or in English-language scientific publications in general. Nevertheless, in Russian-language publications, both demographic cycles and the relationship between cyclicality in economics and demography are quite actively studied.

Based on the results of a mathematical analysis of the medium-term fertility trend in Latvia obtained by the authors, it can be expected that the decline in fertility in the country will continue for several more years before the bottom of the next demographic cycle is reached. This bottom value will be lower than the previous one of less than 1.22—1. 25 children on average per woman. There is an anticipated turn towards increasing fertility levels within an overall declining trend. However, this projected increase is unlikely to surpass the previous peak. Specifically, the next maximum of the demographic cycle in terms of the Total Fertility Rate (TFR) is expected to be less than 1.74 children on average per woman. Consequently, the desired and even expected increase in the TFR in Latvia to 1.77 children per woman by 2027, as envisioned in the "FAMILY — LATVIA — 2030 (2050) Population Reproduction Strategy," is considered practically unattainable by the authors of this study.

The application of the mathematical analysis to the study of fertility trends showed that it is methodologically incorrect to conduct a superficial linear analysis of demographic data, as is often done in Latvia. At the same time, based on the concept of demographic cycles used by the authors of this study, it can be argued that the studied time period of 53 years is most likely part of a longer-term demographic cycle, which is not fully covered by this study and thereby limits the application of its results in the long-term perspective.

A demographically significant direction for further study of the topic for the safety of the state is the analysis of natural population growth/decline in the regions of Latvia, as well as the economic and non-economic factors that determine them: the gender and age structure of the population, birth and death rates, the development of the regional economy, sociocultural changes in society that contribute to the growth of fertility rates.

References

1. Zvidrins, P. 1979, The dynamics of fertility in Latvia, *Population Studies,* vol. 33, № 2, p. 277—282, https://doi.org/10.2307/2173532

2. Krišjāne, Z., Krūmiņš, J. (zin. red.). 2019, *Tautas ataudze Latvijā un sabiedrības atjaunošanas izaicinājumi*, Rīga, LU Akadēmiskais apgāds, 300 lpp., https://doi.org/10.22364/talsai

3. Tretjakova, V., Gedvilaitė-Kordušienė, M., Rapolienė, G. 2020, Women's pathways to childlessness in Lithuania, *Sociālo Zinātņu Vēstnesis [Social Sciences Bulletin]*, № 2, p. 7—21.

4. Pourreza, A., Sadeghi, A., Amini-Rarani, M., Khodayari-Zarnaq, R., Jafari, H. 2021, Contributing factors to the total fertility rate declining trend in the Middle East and North Africa: a systemic review, *Journal of Health, Population and Nutrition*, № 40, 11, https://doi.org/10.1186/s41043-021-00239-w

5. Skirbekk, V. 2022, Decline and Prosper: Changing Global Birth Rates and the Advantages of Fewer Children, First edition, Palgrave Macmillan Cham, 396 p., https://doi.org/10.1007/978-3-030-91611-4

6. Martynov, V. L., Sazonova, I. Ye. 2023, Population change and the settlement system transformation in Poland, as revealed by the 2021 census, *Baltic Region*, vol. 15, № 2, p. 41—61, https://doi.org/10.5922/2079-8555-2023-2-3

7. Adhia, N. 2018, Some demographic trends in the world's most populous country-to-be, vol. 23, № 2, p. 5—8.

8. Ryazantsev, S. V. (ed.). 2021, Demographic development of post-Soviet countries (1991—2021): trends, demographic policy, prospects, Moscow, ITD "Perspektiva", https://doi.org/10.19181/monogr.978-5-89697-379-9.2021

9. Deshpande, J. V. 2004, *Mathematical Analysis and Applications: An Introduction,* First edition, Alpha Science.

10. Brannan, D. A. 2006, *A First Course in Mathematical Analysis*, Cambridge, Cambridge University Press, https://doi.org/10.1017/CBO9780511803949

11. Volodko, I. 2007, *Augstākā matemātika*, I daļa, Rīga, Zvaigzne ABC.

12. Van de Kaa, D. J. 1987, Europe's second demographic transition, *Population Bulletin*, vol. 42, № (1), p. 1—59.

13. Sobotka, T. 2008, Overview Chapter 6: The diverse faces of the second demographic transition in Europe, *Demographic Research*, vol. 19, p. 171—222, https://doi.org/10.4054/DemRes.2008.19.8

14. Krūmiņš, J., Krišjāne, Z. 2016, Demogrāfiskā attīstība Latvijā: problēmas un izaicinājumi, *LZA Vēstis=Bulletin of the Latvia Academy of Sciences*, A. dala, p. 40—50.

15. Lesthaeghe, R. 2020, The second demographic transition, 1986—2020: sub-replacement fertility and rising cohabitation — a global update, *Genus*, № 76, 10, https://doi.org/10.1186/s41118-020-00077-4

16. Coleman, D. 2006, Immigration and ethnic change in low-fertility countries: a Third Demographic Transition, *Population and Development Review*, vol. 32, № 3, p. 401—446.

17. May, J. F. 2012, *World Population Policies. Their Origin, Evolution, and Impact*, Springer Dordrecht, https://doi.org/10.1007/978-94-007-2837-0

18. Bērziņš, A. 2019, Dzimstības izmaiņas, In: Krišjāne, Z., Krūmiņš, J. (zin. red.), *Tautas ataudze Latvijā un sabiedrības atjaunošanas izaicinājumi*, Rīga, LU Akadēmiskais apgāds, p. 155—163, https://doi.org/10.22364/talsai

19. Sherry, C. J., Sherry, J. W. 2000, *The Mathematics of Technical Analysis*: *Applying Statistics to Trading Stocks, Options and Futures,* iUniverse.

20. Hilkevics, S., Pulkstene, A. 2019, The consideration of the methodology for the evaluation of the financial condition of Baltic stock companies, *Proceedings of the International Scientific Conference "Social Sciences for Regional Development 2018", Part III: Issues of Economics*, Daugavpils: Daugavpils University Academic Publishing House "Saule", p. 16—23.

21. Revina, I. 2002, *Ekonometrija,* Rīga, LU Akadēmiskais apgāds.

22. Korotaev, A. V., Tsirel, S. V. 2010, Kondratiev waves in world economic dynamics, In: Khalturina, D. A., Korotaev, A. V. (ed.), System monitoring, Global and regional development, M., Librocom/URSS, p. 189—229 (in Russ.).

23. Ovechkina, N. I., Shulgina, N. A. Cyclicity theory in economics and demography, *Vestnik NSUEM*, 2012, № 2, p. 105—110 (in Russ.).

24. Belov, A. A., Danilov, A. N., Rotman, D. G. 2023, Value factor of the countries uneven development, *RUDN Journal of Sociology*, vol. 23, № 2, p. 244—255, https://doi.org/10.22363/2313-2272-2023-23-2-244-255

25. Stepin, V. S. 2019, Man. Activity. Culture, St. Petersburg, SPbGUP (in Russ.).

26. Hofstede, G. 2001, *Culture's Consequences: Comparing Values, Behaviours, Institutions and Organizations Across Countries*, CA, Sage, Thousand Oaks.

27. Mietule, I., Komarova, V., Ostrovska, I., Ignatyevs, S., Heimanis, B. 2022, Economic texts as a reflection of the social reality of the transition period in Latvia and Russia, *RUDN Journal of Sociology*, vol. 22, № 1, p. 168—185, https://doi.org/10.22363/2313-2272-2022-22-1-168-185

28. Voronov, V. V., Ruza, O. P. 2018, Youth unemployment in the Latgale region of Latvia: causes and consequences, *Baltic Region*, vol. 10, № 4, p. 88—102, https://doi.org/10.5922/2079-8555-2018-4-6

29. Voronov, V. V. 2022, Small towns of Latvia: disparities in regional and urban development, *Baltic Region*, vol. 14, № 4, p. 39—56, https://doi.org/10.5922/2079-8555-2022-4-3

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HEALTH EXPENDITURES AND HEALTH OUTCOMES IN CENTRAL EUROPE AND THE BALTIC REGION

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In Central Europe and the Baltic region, healthcare expenditure has been growing slightly faster than across the euro area and in OECD countries. However, health outcomes as regards chronic diseases prove to be modest in the euro area and OECD countries compared to Central Europe and the Baltic region. Panel data analysis and country-specific regressions were conducted using World Bank data spanning from 2000 to 2019. Evidence suggests a significant correlation between private and current health expenditures and reduced mortality from chronic diseases in males, females and the total population across the panel, leading to improved longevity. Yet, public health expenditure does not correlate with a substantial reduction in mortality or a higher lifespan among the population, whether considered collectively or among males and females separately. Similarly, an increase in current health expenditure by one unit leads to significant reductions in mortality from non-communicable diseases: by 29 percent in the total population, 22 percent in females and 36 percent in males. Public health spending in Lithuania and Russia has been shown to decrease mortality from non-communicable diseases. Furthermore, chronic mortality is associated with a significant decline in labour productivity: by 42 percent in the total population, 40 percent in males and 45 percent in females. Therefore, interventions implemented through public health systems may reduce mortality from chronic conditions in the study countries.

Keywords:
Baltic region, health expenditures, health outcomes, seemingly unrelated regression

Introduction

The exponential growth rate of health expenditures has become a concern to policymakers. In this context, a fundamental issue in contemporary debates on health policy revolves around the extent to which increased healthcare spend-

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ing results in the anticipated benefits, such as reduced mortality across various conditions and extended life expectancy among the population. In previous empirical studies, the dynamics of health expenditure and health outcomes appear difficult to disentangle. For instance, Leu concludes that medical spending is not significantly associated with lower mortality [1]. Hitiris et al. argue that there is scant evidence supporting the notion that increased health expenditure reduces mortality rates in developed countries [2]. Nixon and colleagues have found a correlation between increased medical expenditure and a notable reduction in infant mortality [3]. Caroline et al. have established that lower health expenditure is linked to higher infant mortality rates and reduced life expectancy in Canada [4]. Ullah and his co-researchers have demonstrated that higher public health expenditure leads to substantially improved health outcomes in Pakistan [5]. Oladosu's study reveals that despite relatively low levels of public health expenditure in Nigeria and Ghana, it still contributes significantly to improved health outcomes [6]. Singh's findings indicate that increased public health spending reduces mortality rates for children under five, also from non-communicable diseases (NCDs), while also enhancing life expectancy. However, only in Brunei and Singapore did private health spending improve health outcomes among the countries of Southeast Asia [7]. Similarly, Ivankova et al. established that higher health spending is significantly associated with lower mortality for treatable respiratory diseases for both males and females in OECD countries [8]. Arthur's research shows that health expenditure has a significant, though inelastic, impact on health outcomes in the Sub-Saharan African continent [9]. Akinkugbe et al. have found that among other factors considered in the model, public health spending determines health status in Lesotho [10]. Anyanwu's analysis indicates that under-five and infant mortality rates are significantly associated with government health expenditures in Africa [11]. Hlafa's research reveals that the impact of public health spending on health outcomes varied across the nine provinces of South Africa [12]. Kumar et al. have found that public expenditure on health has little effect on mortality reduction (infant and under-five) in India [13]. Novignon has found that public and private health spending improves health status in Africa [14]. Rahman and colleagues have found that both public and private expenditures reduced infant mortality rates in Southeast Asian countries [15]. Heuvel's research indicates that social protection expenditures, rather than healthcare expenditures, are the major drivers of longevity in a comparative study of European countries [17]. Anwar's investigation into OECD countries concluded that health expenditures negatively impact infant mortality and positively impact life expectancy [18]. Longitudinal studies by Roffia et al. on OECD countries indicate that healthcare expenditures, physician density, temperature, and population density significantly impact life expectancy at birth [19]. Linden et al. in the study on OECD countries, found evidence supporting a positive link between both public and private health expenditures and life expectancy at birth [20].

However, this research investigates whether different components of health expenditures are significantly associated with better health outcomes within and across the countries of Central Europe and the Baltic region. The rest of this paper has the following arrangement. The methods follow in section two, and the result is analysed in section three. Section four discusses the results, and section five concludes this research.

Methods

Primarily, this paper investigates the impact of different components of health expenditures on health outcomes in the context of Central Europe and the Baltic region. The components of health expenditures employed are per capita public health expenditure (Pub. Hea. Exp.), per capita private health expenditure (Pvt. Hea. Exp.), per capita current health expenditure (Crn. Hea. Exp.). Similarly, the variables employed as health outcomes are life expectancy at birth (total) (Lyf. Exp. at birth {total}), life expectancy at birth (female) (Lyf. Exp. at birth {female}), life expectancy at birth (male) (Lyf. Exp. at birth {male}), mortality rate from chronic diseases (total) (NCDs mort. {total}), mortality rate from chronic diseases (female) (NCDs mort. {female}), mortality rate from chronic diseases (male) (NCDs mort. {male}). The general form of the parametric model seeks to investigate whether different components of per capita health expenditures are significantly associated with improvement in health outcomes (mortality reductions from chronic diseases and higher life expectancy). Therefore, the baseline of the model can be written in a log-linear form as:

$$HealthOutcome_{it} = \alpha_0 + \beta_1 ln(pubhexp_{it}) + \beta_2 ln\left(pvthexp_{it}\right) + \beta_3 \ln\left(Crnhexp_{it}\right) + \\ + \beta_4 \ln\left(lbpro_{it}\right) + \beta_5 \ln\left(depop_{it}\right) + \varepsilon_{it}.$$

In this model, it is assumed that $\beta_1$measures the elasticity coefficient of per capita Pub. Hea. Exp., β_2 for per capita Pvt. Hea. Exp., β_3 for per capita Crn. Hea. Exp., β_4 for the productivity of labour and β_5 for the elderly population. The health outcomes are the dependent variables of this model and are taken as NCDs mortality (total), NCDs mortality (female), NCDs mortality (male), Lyf. Exp. at birth (total), Lyf. Exp. at birth (female), Lyf. Exp. at birth (male). In addition, α_0 is a constant term that measures the country-specific effect in the regression and ε_{it} is the composite error that takes into account the unaccounted errors in the regression, and thus, it is assumed to be independently and normally distributed. Importantly, in line with economic theories, the size of per capita health expenditure is a strong indicator of the share of funding a particular health system receives. Therefore, all else is held constant; health expenditures are expected to lower mortality rates from all conditions and better the life span of the population in the health system. Thus, an increase in different components of per capita health expenditures should be central to ensuring wider and greater access

to health services, leading to improved health outcomes. This paper follows the decomposition method of Cheng and colleagues [16] by taking the ratio of some of the variables considered in the model.

Table 1

Definition and the variables

Variable	Definition
Per capita public health expenditure (PPP* USD)	The ratio of domestic government health expenditure per capita to GDP per capita
Per capita private health expenditure (PPP USD)	The ratio of domestic private health expenditure per capita to GDP per capita
Per capita current health expenditure (PPP USD)	The ratio of current health expenditure per capita to GDP per capita
Labor productivity	The ratio of the working population to the total population
Dependent population	The ratio of the elderly population to the total population
Life expectancy at birth (total)	The average years an individual is expected to live in a country (total)
Life expectancy at birth (female)	The average years an individual is expected to live in a country (female)
Life expectancy at birth (male)	The average years an individual is expected to live in a country (male)
Mortality rate from chronic diseases (total)	The number of deaths specific to cancer, diabetes, cardiovascular, and respiratory diseases in a country (total)
Mortality rate from chronic diseases (female)	The number of deaths specific to cancer, diabetes, cardiovascular, and respiratory diseases in a country (female)
Mortality rate from chronic diseases (male)	The number of deaths specific to cancer, diabetes, cardiovascular, and respiratory diseases in a country (male)

Note: * PPP means Purchasing Power Parity.

The data is obtained from the World Bank Development Indicators spanning 2000 to 2019. The countries for this study are Denmark, Estonia, Finland, Germany, Iceland, Latvia, Lithuania, Norway, Poland, Russia, and Sweden. The variables employed in this study and their definition is given in Table 1. The different components of per capita health expenditure employed are measured in terms of international purchasing power parity in each country. The mortality rate is measured per 1,000 population in each country and across gender groups. The data is analysed using STATA version 15.1.

Results

Figure 1 in the appendix section illustrates the trends in different components of health expenditures specific to Central Europe and the Baltic region, the Euro Area, and the OECD countries. In the Central Europe and the Baltic region, Crn.

Hea. Exp. maintains a steady upward trend from 2000 to 2010, and the trend changes slowly, and towards the end of the sample, it continues to rise without a sign of a decline. Similarly, Pub. Hea. Exp. increases slowly at the beginning of the sample, changes trend after 2009, thereafter, it starts declining until 2016 and finally continues to rise slowly. Pvt Hea. Exp. grew steadily without any form of contraction throughout the sample period. However, for the OECD countries and the Euro Area, the data shows the same patterns — Crn. Hea. Exp. and Pub. Hea. Exp. grew in a similar trend, rising slowly, and eventually changing patterns as the sample continued to expand. The Pvt. Hea. Exp. increased slowly until 2009; thereafter, it grew and declined steadily as it approached the end of the sample. Therefore, the trend analysis shows that the OECD countries and the Euro Area have shown similar growth trends in the three components of health expenditures. However, in Central Europe and the Baltic region, the growth trend is comparatively lower for the Pub. Hea. Exp. and Pvt. Hea. Exp. relative to the Crn. Hea. Exp.

In the panel analysis, the Hausman test can be used to decide whether to choose a fixed effect (FE) or a random effects (RE) model. In this case, the null hypothesis for a Hausman specification test is that the RE model is more efficient. On the other hand, the alternative hypothesis tells that the FE model is the prepared model, assuming that the RE model is inconsistent. Thus, applying the Hausman test helps to decide the most consistent and efficient estimates between the FE and the RE models. Specifically, if the results indicate p-values smaller than 0.05, the FE model is chosen. Conversely, if the *p*-value is greater than 0.05, the RE model is chosen. The FE estimates of health outcomes regressions are shown in Table 2. Across the panel, the estimate indicates that per capita private and current health expenditures improved health outcomes significantly. This implied that a unit rise in per capita private and current health expenditure would lower the mortality rate from chronic conditions by 5 % and 29 % in the entire population, specifically for the Crn. Hea. Exp, the reduction is even higher, 32 % for males relative to females value of 26 %. Similarly, an increase in per capita private and current health expenditure by one unit will increase life expectancy at birth by 1 % and 5 %, respectively. In the same way, per capita Pvt. Hea. Exp. is associated with a greater impact on life expectancy at birth for females, 7 %, compared to 1 % for males. However, there is no sufficient evidence to say that public health expenditure improves health outcomes in Central Europe and the Baltic region.

Figure 2 in the appendix section illustrates the trend in NCDs mortality in Central Europe and the Baltic region, the Euro Area, and the OECD countries. In Central Europe and the Baltic region, NCDs mortality declines gradually in the same direction for the entire population, males and females. However, in the Euro Area and the OECD countries, a similar pattern is observed in the mortality declines for chronic conditions in the entire population and across gender

groups. This highlights that there is lower NCDs mortality in the Euro Area and the OECD countries relative to Central Europe and the Baltic region. Figure 3 in the appendix section portrays the trends in NCDs mortality in Central Europe, the Baltic region, the Euro Area, and the OECD countries. In the Central Europe and the Baltic region, Lyf. Exp. at birth increases steadily for the entire population and across gender groups without significant variations. In the Euro Area, it expanded steadily until 2015, suddenly declined in 2016, and continued to grow towards the end of the sample. However, in the OECD countries, it expanded greatly without any form of contraction throughout the sample period.

Moreover, the mortality rate from chronic conditions is significantly associated with a lower level of labour productivity and an increased dependent population for males, females, and the total population. This suggests that a substantial share of the active labour force and the elderly population are dying from chronic conditions in these countries, resulting in a 42 % reduction in labour productivity across the entire population. It is important to note that the percentage decline in labour productivity (42 %) due to sudden death from chronic diseases is considerably higher than the overall contribution of labour productivity to raising life expectancy at birth (6 %) in the total population. Similarly, the estimates indicate that 48 % of the elderly are dying from chronic conditions, while the contribution of the elderly population to raising life expectancy at birth is a mere 3 %.

Table 2

Estimates of the Fixed Effects Regression Model

Variable	NCDs mort			Lyf. Exp.		
	total	female	male	total	female	male
Per capita Pub. Hea. Exp.	0.01 (0.57)	0.02 (1.10)	0.01 (0.28)	– 0.01 (– 0.29)	– 0.02 (– 0.71)	0.01 (– 0.04)
Per capita Pvt. Hea. Exp.	– 0.05 (– 3.2)***	– 0.05 (– 3.3)***	– 0.05 (– 2.8)***	0.01 (3.14)***	0.07 (3.00)***	0.01 (3.07)***
Per capita Crnt. Hea. Exp.	– 0.29 (10.4)***	– 0.26 (– 9.4)***	– 0.32 (– 9.8)***	0.05 (8.47)***	0.04 (9.20)***	0.06 (7.66)***
Labour productivity	– 0.42 (– 11.3)***	– 0.45 (– 12.8)***	– 0.40 (– 9.6)***	0.06 (7.57)***	0.05 (9.08)***	0.07 (6.34)***
Dependent population	– 0.48 (– 10.5) ***	– 0.39 (– 8.8)***	– 0.54 (– 10.3)***	0.03 (3.43)***	0.02 (3.62)***	0.04 (3.10)***
Constant	12.1 (16.8)***	10.6 (15.4)****	13.0 (16.0)****	3.5 (24.0)***	3.76 (35.7)***	3.29 (16.4)***

Note: *** indicates significance at 1 %.

Similarly, Table 3 presents the RE regression between health expenditures and health outcomes. The FE and RE models have shown almost the same results regarding the sign and statistical significance of the parameters employed. In this case, per capita private and current health expenditure reduces the NCDs mortality rate for the total population and males and females. Equally, it significantly improves the life span of the male and female. However, it does not better the lifespan of the total population. The result shows that per capita Pub. Hea. Exp. is not associated with a significant improvement in health outcomes across the panel. The estimates of the RE model differ from those of the FE model regarding the coefficient of life expectancy at birth in relation to labour productivity and the dependent population.

Table 3

Estimates of the Random Effects Regression Model

Variable	NCDs mort			Lyf. Exp.		
	total	female	male	total	female	male
Per capita Pvt. Hea. Exp.	−0.04 (−2.8)***	−0.05 (−3.8)***	−0.04 (−2.1)***	−0.04 (−2.75)***	0.01 (3.18)***	0.01 (2.1)**
Per capita Crnt. Hexp	−0.34 (−15.3)***	−0.28 (−13.7)***	−0.38 (−14.6)***	−0.34 (−15.3)***	0.04 (15.8)***	0.08 (14.5)***
Labour productivity	−0.35 (−10.7)***	−0.39 (−13.3)***	−0.33 (−8.9)***	−0.35 (−10.7)***	0.05 (11.8)***	0.07 (9.33)***
Dependent population	−0.11 (−4.1)***	−0.13 (−4.5)***	−0.13 (−4.3)***	−0.11 (−4.1)***	0.01 (1.32)***	0.01 (1.47)
Constant	5.8 (11.2) ***	6.2 (11.9) ***	6.1 (10.4) ***	5.8 (11.2)***	4.13 (63.3)***	3.92 (32.8)***

Note: ***, **, * indicates significance at 5, 10 % and 1 %, respectively.

The Hausman specification test is performed, and the results show *Chi*-square values of 92.887, 153.075, and 158.0 for total, female and male, respectively, with corresponding *p*-values of 0.000, 0.000 and 0.001 for health outcomes specific to NCDs mortality regressions. This suggests that the null hypothesis is rejected, and thus, the FE model is the most efficient model for estimating the dynamics of different health expenditures and reductions in mortality from chronic conditions. In addition, the Hausman test shows Chi-square values of 326.00, 16.375, and 20.882 for total, female and male health outcomes specific

to life expectancy at birth, with statistically significant *p*-values of 0.001, 0.006, and 0.001, respectively. This indicates that the alternative hypothesis is accepted; thus, the FE regression model is chosen as the prepared model.

Table 4

Estimates of the seemingly unrelated regression model for public health expenditure and health outcomes

Country	NCDs mortality			Lyf. Exp. at birt		
	total	female	male	total	female	male
Denmark	26.7 (2.79)***	−16.1 (−1.48)	0.01 (1.81)	−2.00 (−1.20)	1.47 (2.17)***	−1.28 (−1.17)
Estonia	8.50 (2.08)***	4.62 (0.87)	0.01 (2.10)**	−1.45 (−3.20)***	−1.59 (−4.56)***	−0.03 (−0.07)
Finland	0.08 (0.03)	19.9 (4.85)***	0.02 (0.20)	0.95 (0.35)	−1.81 (−1.52)	−1.45 (−0.82)
Germany	67.4 (0.65)	−50.3 (−0.38)	0.03 (0.41)	−65.2 (−1.87)	23.5 (1.82)	36.4 (1.56)
Iceland	−2.18 (−0.58)	20.0 (4.66)***	0.03 (0.34)	−0.98 (−2.44)***	−2.73 (−2.55)	0.40 (1.98)
Latvia	17.0 (2.33) ***	−0.19 (−0.02)	0.02 (0.21)	−2.30 (−1.00)	−2.73 (−1.46)	2.48 (2.84)***
Lithuania	−25.9 (2.09)***	56.7 (3.26)***	0.04 (0.31)	−7.43 (−1.30)	−3.12 (−4.2)***	7.74 (1.43)
Norway	9.19 (2.76)***	9.14 (2.04)***	0.06 (0.40)	2.06 (0.66)	−2.64 (−1.27)	−0.93 (−0.77)
Poland	9.43 (0.08)	14.0 (2.29)***	0.01 (0.34)	−21.2 (3.28)***	4.02 (1.86)	12.8 (2.92)***
Russia	−53.3 (−4.61)***	88.4 (5.39)***	0.01 (0.13)	−28.4 (−3.57)***	−1.81 (−0.39)	30.9 (7.57)***
Sweden	35.9 (7.02)***	−18.2 (−2.80)***	0.02 (0.24)	3.09 (1.51)	−2.07 (−2.15)***	−2.87 (2.37)***

Note: ***, **, * indicates significance at 5, 10 % and 1 %, respectively.

Figures in parenthesis are z-values NCDs mort mean mortality rates from chronic diseases, and Lexp means life expectancy at birth.

Furthermore, a country-specific analysis of the impact of per capita public, private, and current health expenditures on health outcomes is performed using the analytical technique of multiple equation model popularly known as Seemingly Unrelated Regression (SUR). Applying SUR to this analysis will give a clearer understanding of the dynamics of each component of health expenditures on health outcomes specific to each country under investigation, which the aggregate analysis will not highlight. Therefore, using SUR would yield more efficient results and allow for comparison across the panel. Table 3 shows the country-specific estimates of the impact of per capita Pub. Hea. Exp. on health

outcomes, other explanatory variables of the model are held constant. The coefficient of the estimates differs between male and female and the total population specific to each of the health outcomes. For instance, the coefficient of Pub. Hea. Exp. rightly contributes to reductions in NCDs mortality (total) only in Lithuania and Russia. Though it is not significant, it contributes to mortality reductions in Iceland. However, in Denmark, Estonia, Latvia, and Norway, the estimates are significant but do not contribute to a lower mortality rate for the total population. Additionally, only in Sweden, Pub. Hea. Exp. significantly lower NCDs mortality (female), and it does the same in Estonia for NCDs mortality (male). Moreover, in Denmark, Pub. Hea. Exp. only improved Lyf. Exp. at birth (female), and it does the same in Latvia, Norway, and Russia for Lyf. Exp. at birth (male).

Table 5

Estimates of the seemingly unrelated regression model for private health expenditure and health outcomes

Country	NCDs mortality			Lyf. Exp. at birth		
	total	female	male	total	female	male
Denmark	45.4 (4.63)***	37.2 (−11.2)***	2.34 (0.23)	−1.62 (−0.70)	1.70 (1.82)	−1.91 (−1.25)
Estonia	6.13 (0.65)	10.7 (0.87)	1.23 (1.23)	−1.19 (−1.23)	−4.63 (−6.40)***	2.52 (3.22)***
Finland	117.4 (3.61)***	−125.9 (−3.06)***	2.01 (0.89)	−2.32 (−0.13)	2.57 (0.47)	−4.02 (−0.34)
Germany	53.6 (5.93)***	−43.9 (−3.81)***	0.06 (0.06)	−6.69 (−3.01)***	3.69 (4.56)***	0.70 (0.47)
Iceland	16.9 (2.44)***	7.06 (0.85)	0.12 (0.07)	2.23 (−3.89)***	0.07 (0.11)	−0.74 (−2.48)
Latvia	6.53 (1.16)	9.59 (1.270)	0.34 (1.01)	−0.10 (−0.08)	−2.90 (−2.80)	0.32 (0.66)
Lithuania	−15.4 (−1.23)	44.3 (2.57)***	0.21 (1.14)	27.8 (−1.30)	−1.24 (−2.66)***	−14.9 (0.94)
Norway	5.27 (1.22)	8.51 (1.48)	1.23 (0.56)	0.99 (0.35)	−1.86 (−0.98)	−0.20 (−0.18)
Poland	9.74 (2.06)**	13.4 (2.52)***	1.43 (1.03)	7.21 (1.08)	−5.55 (−2.48)***	−5.51 (−1.21)
Russia	−5.58 (−0.43)	22.6 (1.23)	2.45 (1.43)	−2.99 (−0.43)	−14.4 (−3.5)*	17.7 (4.91)*
Sweden	52.3 (6.64)***	−36.7 (−3.7)***	1.67 (1.32)	−3.64 (−1.29)	1.23 (0.93)	0.54 (0.32)

Note: ***, **, * indicates significance at 5, 10 % and 1 %, respectively.

Figures in parenthesis are z-values NCDs mort mean mortality rates from chronic diseases, and Lexp means life expectancy at birth.

Table 5 shows the dynamics of per capita Pvt. Hea. Exp. and health outcomes obtained using the country-specific regression. Though statistically significant, per capita Pvt. Hea. Exp. is not associated with NCDs mortality (total) reductions in Denmark, Finland, Germany, Poland, and Sweden. In contrast, per capita Pvt. Hea. Exp. is significantly associated with reductions in NCDs mortality (female) in Finland, Germany, and Sweden. However, for NCDs mortality (male), no significant impact is observed in any country of the panel. In the same way, in Iceland Pvt. Hea. Exp. contributes significantly to higher Lyf. Exp. at birth (total), in Germany, Lyf. Exp. at birth (female), and in Estonia Lyf. Exp. at birth (male). However, in Lithuania, Norway, and Poland, Pvt. Hea. Exp. is associated with an increase in Lyf. Exp. at birth (total) but not significant. The same is the case in Denmark, Finland, Iceland, and Sweden for Lyf. Exp. at birth (female). Further, it was the same case with Germany, Latvia, and Sweden for Lyf. Exp. at birth (male).

Table 6

Estimates of the seemingly unrelated regression model for current health expenditure and health outcomes

Country	NCDs mortality			Lyf. Exp. at birth		
	total	female	male	total	female	male
Denmark	34.9 (4.78)***	−25.1 (−3.04)***	0.65 (1.04)	−1.54 (−0.93)	1.14 (1.71)***	−1.39 (−1.27)
Estonia	10.3 (2.99)***	2.54 (0.57)	1.23 (1.10)	−1.32 (−3.04)***	−1.81 (−5.51)***	−0.09 (0.26)
Finland	6.21 (1.78)	12.0 (2.72)**	1.03 (1.31)	4.87 (2.50)***	−3.16 (−3.61)***	−4.05 (−3.16)
Germany	63.8 (5.37)***	−55.7 (−3.66)***	0.76 (0.98)	−13.8 (−4.85)***	8.91 (8.58)***	3.51 (1.81)
Iceland	2.07 (0.66)	17.5 (4.65)***	1.04 (1.03)	−1.21 (−3.74)***	−0.91 (−2.59)***	0.05 (0.27)
Latvia	10.2 (2.16)***	6.72 (1.07)	1.07 (1.01)	0.05 (0.03)	−3.79 (−2.59)***	1.05 (1.51)
Lithuania	−9.06 (−1.13)	36.0 (3.24)**	0.45 (0.87)	44.0 (2.16)**	−1.42 (3.23)***	−28.9 (−1.93)
Norway	−19.8 (−1.40)	48.0 (2.54)**	1.22 (0.90)	11.1 (1.61)	−10.3 (−2.26)**	−1.15 (−0.43)
Poland	10.4 (1.84)	13.2 (2.09)***	1.34 (0.67)	−13.5 (−2.84)***	0.61 (0.37)	8.59 (2.63)**
Russia	−31.1 (−2.63)***	58.1 (3.48)***	2.10 (1.56)	−18.5 (−2.52)***	−5.64 (1.32)	24.4 (6.57)***
Sweden	63.0 (8.83)***	−44.7 (−4.99)***	1.76 (0.56)	−5.59 (−2.28)***	1.24 (1.09)	−1.98 (1.36)**

Note: ***, **, * indicates significance at 5, 10 % and 1 %, respectively.

Figures in parenthesis are z-values NCDs mort mean mortality rates from chronic diseases, and Lexp means life expectancy at birth.

The estimates of the country-specific regression for the Crn. Hea. Exp. and health outcomes are depicted in Table 6. Evidence shows that only in Russia, Crn. Hea. Exp. is significantly associated with lower NCDs mortality (total). Moreover, in Denmark, Germany, and Sweden, it exerts a significant impact on lower NCDs mortality (female). However, it has no significant impact on lower levels of NCDs mortality (male) across the countries under investigation. Similarly, only in Finland and Lithuania, Crn. Hea. Exp. contributes significantly to higher Lyf. Exp. at birth (total). In Denmark and Germany, it exerts a greater influence on raising Lyf. Exp. at birth (female). In Poland and Russia, it significantly induces higher Lyf. Exp. at birth (male).

Discussion

This study presents interesting findings on the dynamics of the exponential growth in the three components of health expenditures and health outcomes for the countries of Central Europe and the Baltic region. Initially, the paper compares the trends in the growth rate of three components of health expenditures — Crn. Hea. Exp., Pub. Hea. Exp., and Pvt. Hea. Exp. and observed that the trend in growth for Pub. Hea. Exp. and Pvt. Hea. Exp. is comparatively quite low in Central Europe and the Baltic region. However, the trend shows a similar growth pattern for the Euro Area and the OECD countries for the three components of expenditures. The same trend analysis is performed for the variables employed as health outcomes — NCDs mortality (total), NCDs mortality (female), NCDs mortality (male), life expectancy at birth (total), life expectancy at birth (female), and life expectancy at birth (male). It is observed that there is comparatively lower mortality for NCDs in the Euro Area and the OECD countries relative to Central Europe and the Baltic region. Similarly, life expectancy at birth expanded significantly higher in the OECD countries compared to the Euro Area and the Central Europe / Baltic Countries. In addition, the parametric technique of FE and RE models are applied in estimating the model; thus, estimates of the FE model are more efficient.

The panel result highlights that Pvt. Hea. Exp. and Crn. Hea. Exp. are significantly associated with mortality reductions for chronic NCDs and higher life spans for the entire population and for males and females, respectively. Noteworthy, an increase in Pvt. Hea. Exp. by a particular unit is significantly associated with a reduction in NCDs mortality by 5 % for the overall population and for both males and females, respectively. An increase in Crn. Hea. Exp. by one unit is associated with significant reductions in NCDs mortality by 29 % for the total population, 22 % for females, and 36 % for males, respectively. Specific to

Pvt. Hea. Exp., these results are not similar to the results of prior studies conducted by S. Singh et al. [7], M. M. Rahman et al. [15], and J. Novignon et al. [14]. In contrast, Pub. Hea. Exp. is neither associated with a significant reduction in NCDs mortality nor with greater longevity for the entire population and both males and females. These results differ from the results of some previous studies by S. Singh et al. [7], B. Hlafa et al. [12], J. C. Anyanwu et al. [11], and J. Novignon et al. [14]. It is also found that NCDs mortality significantly reduces labour productivity by 42 %, much better than the extent to which labour productivity contributes to raising life expectancy by 6 % in the population. In addition, 48 % of the population is significantly dying from chronic NCDs conditions, and only 3 % of the elderly population is accounted to a higher life span of the population.

Furthermore, estimates of the country-specific regression show that Pub. Hea. Exp. respond to lower NCDs mortality (total) only in Lithuania and Russia. Pub. Hea. Exp. responds to lower NCDs mortality (female) in Sweden and Estonia for lower NCDs mortality (male). In addition, Pub. Hea. Exp. improved life expectancy at birth for (females) in Denmark, Latvia, Norway, and Russia, and it improved life expectancy only for (males). Moreover, across these countries, Pvt. Hea. Exp. is not associated with significant reductions in NCDs mortality (total). However, in Finland and Germany, Pvt. Hea. Exp. responds to lower NCDs mortality (female). This result is consistent with the findings of S. Singh et al. [7] and J. Novignon et al. [14] in their country-level analysis with respect to mortality reductions. In Iceland, it is significantly better for Lyf. Exp. at birth (total), in Germany for Lyf. Exp. at birth (female), and in Estonia for Lyf. Exp. at birth (male). Finally, the estimates of the country-specific regression for the Crn. Hea. Exp. reveals that it significantly responds to lower NCDs mortality (total) only in Russia. The same is true for Denmark, Germany, and Sweden, for lower NCDs mortality (female). In Finland and Lithuania, Crn. Hea. Exp. significantly improve Lyf. Exp. at birth (total), and in Denmark and Germany, it increases Lyf. Exp. at birth (female). In Poland and Russia, it significantly induces higher Lyf. Exp. at birth (male).

Therefore, these results could inform policy decisions in these countries. If health outcomes are to be improved in Central Europe and the Baltic region, priority should be given to private health financing relative to other forms of financing in the health system. However, this alone will not improve outcomes specific to chronic conditions unless lifestyle and dietary levels are altered. If this

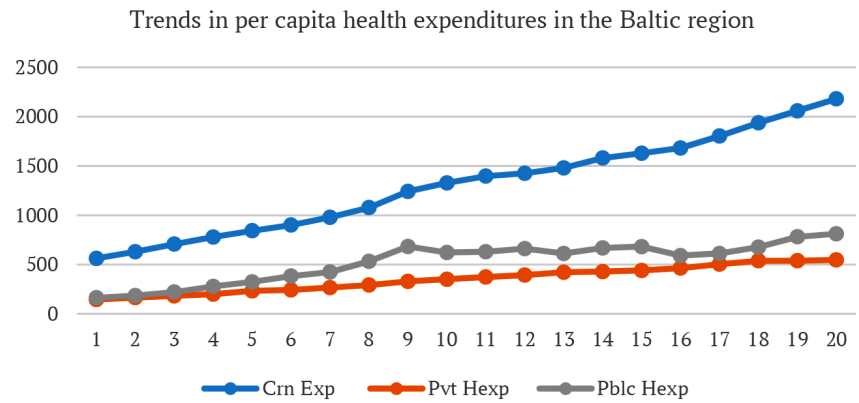
is the case, a combined approach channelled through private sector dominance is highly needed to achieve improvement in health outcomes that correspond with increased health expenditures.

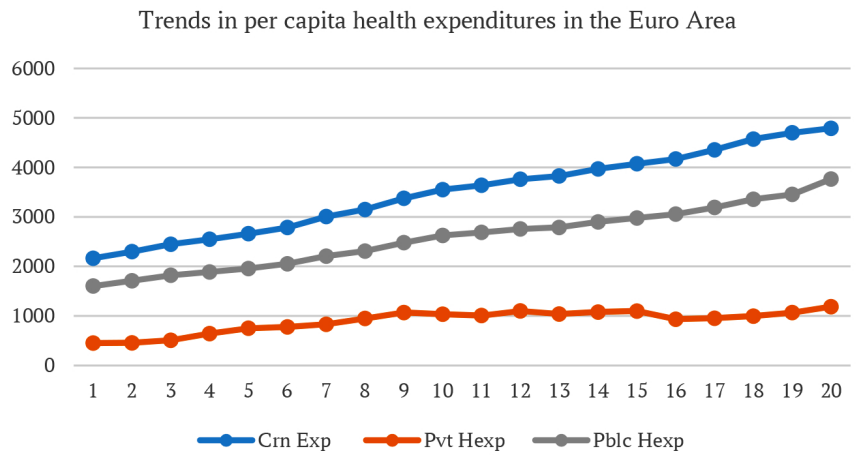
Potential limitations of this study may include an over-reliance on available panel data regarding the factors affecting health outcomes. Additionally, lifestyle and dietary patterns significantly influence health outcomes, but panel data on these variables is not freely accessible to the authors. The methodology generally assumes that an increase in health expenditure will lead to improved health outcomes. However, if health expenditures are not efficiently utilised, or if there are inequities in the utilisation of healthcare resources, an increase in health expenditure may not yield the anticipated benefits for the population.

Conclusion

This study investigates the dynamics of three components of health expenditures on health outcomes in Central Europe and the Baltic region for the 2000 to 2019 period. The technique of panel data regression and seemingly unrelated regression is applied to the data for the panel and the country-specific analysis. It is found that Pvt. Hea. Exp. and Crn. Hea. Exp. are associated with better health outcomes. Therefore, an increase in private health expenditure by a particular unit is significantly associated with a reduction in NCDs mortality by 5 % for the overall population and for both males and females. To policymakers in these countries, private health spending could be a potent way to lower the burden of NCDs mortality. An increase in current health expenditure by one unit is associated with significant reductions in NCDs mortality by 29 % for the total population, 22 % for females, and 36 % for males. Thus, current health expenditure could be more effective in reducing the burden of NCDs in the studied countries. In addition, Pub. Hea. Exp. is neither associated with a significant reduction in NCDs mortality nor a higher longevity across the panel. However, at a country-level analysis, it is found that Pub. Hea. Exp. responds to reduced NCDs mortality (total) in Russia and Sweden for females. Similarly, Pvt. Hea. Exp. reduces NCDs mortality (female) only in Finland, Germany, and Sweden. In Russia, Crn. Hea. Exp. is associated with lower NCDs mortality (total). Overall, Pvt. Hea. Exp. and Crn. Hea. Exp. are significantly associated with better health outcomes within and across countries. However, a significant difference is observed between the total population, males and females. What may have been responsible for a lower level of health expenditures' elasticity for males relative to females may warrant a future investigation.

Appendix





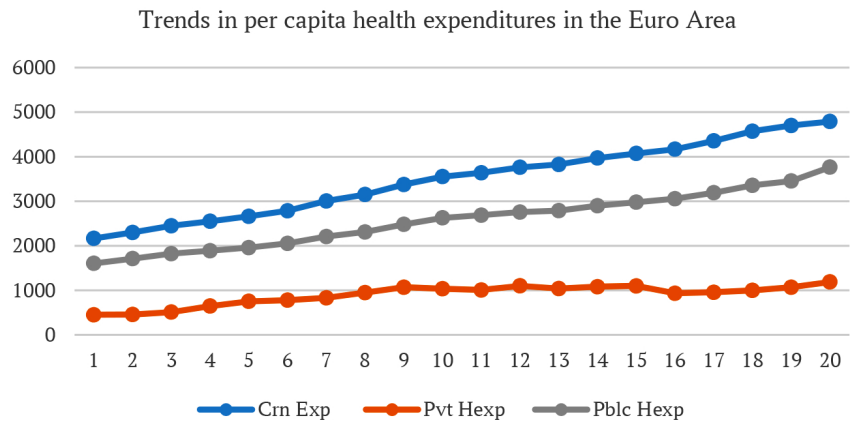
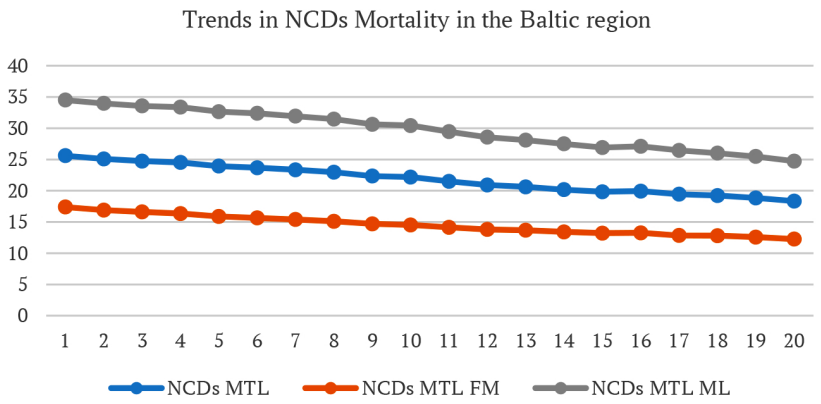
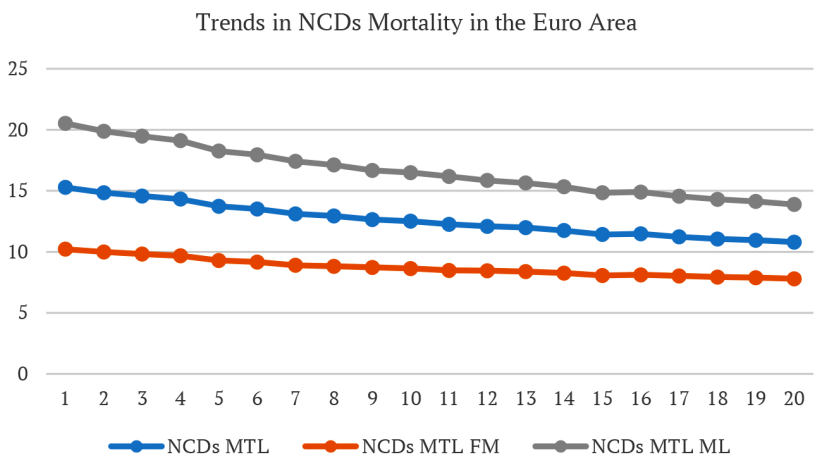


Fig. 1. Trends in per capita health expenditures in the selected region of the world





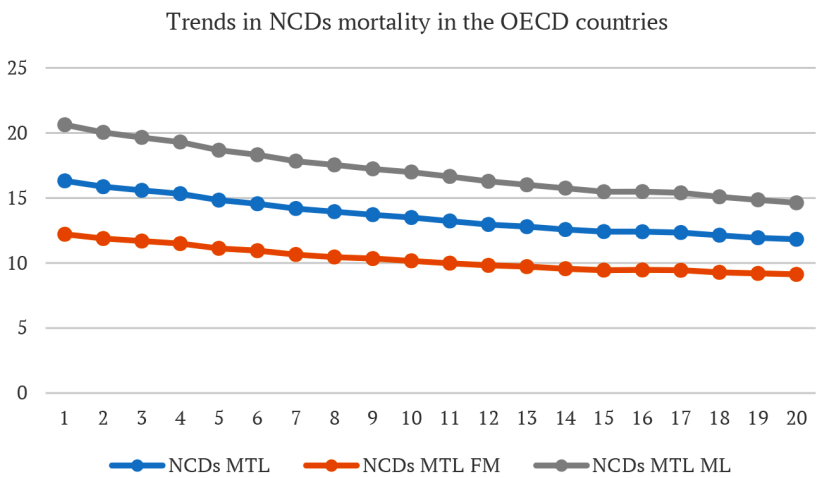


Fig. 2. Trends in NCDs mortality in the selected region of the World

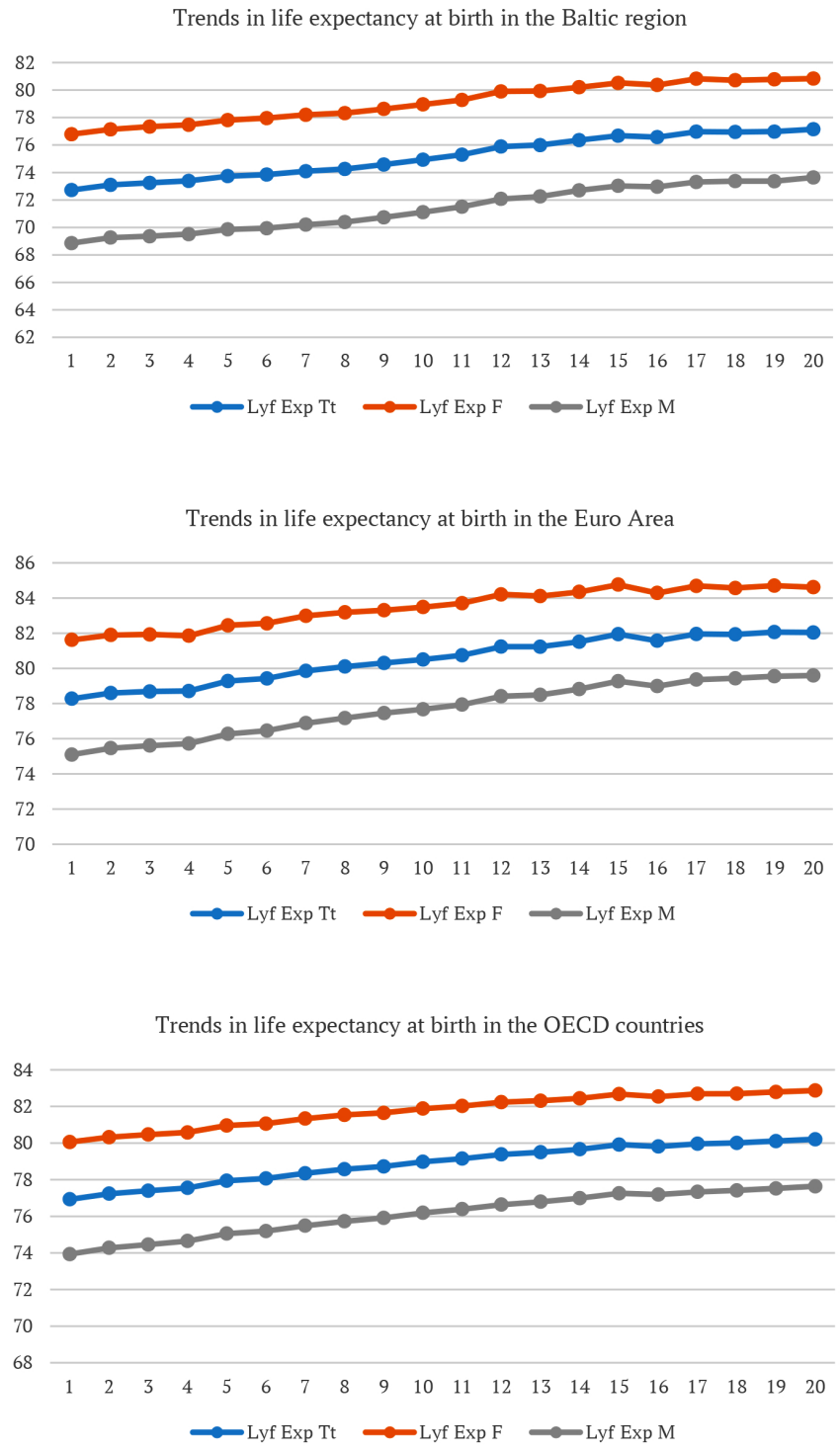


Fig. 3. Trends in life expectancy at birth in the selected region of the World

Link to Dataset: https://data.mendeley.com/preview/mn8hmfg5pm

References

1. Leu, R. E. 1986, The Public-Private Mix and International Health Care Costs, in: Cuyler, A. J., Jönsson, B. (eds.), *Public and Private Health Services,* Basil Blackwell, p. 41—63.

2. Hitiris, T., Posnett, J. 1992, The determinants and effects of health expenditure in developed countries, *Journal of Health Economics*, vol. 11, № 2, p. 173—181, https://doi.org/10.1016/0167-6296(92)90033-w

3. Nixon, J., Ulmann, P. 2006, The relationship between health care expenditure and health outcomes: evidence and caveats for a causal link, *European Journal of Health Economics*, vol. 7, № 1, p. 7—18, https://doi.org/10.1007/s10198-005-0336-8

4. Crémieux, P., Ouellette, P., Pilon, C. 1999, Health care spending as determinants of health outcomes, *Health Economics,* vol. 8, № 7, p. 627—639, https://doi.org/10.1002/(SICI)1099-1050(199911)8:7<627::AID-HEC474>3.0.CO;2-8

5. Ullah, I., Ullah, A., Ali, S. et al. 2021, Public health expenditures and health outcomes in Pakistan: evidence from quantile autoregressive distributed lag model, *Risk Management and Healthcare Policy*, vol. 14, p. 3893—3909, https://doi.org/10.2147/RMHP.S316844

6. Oladosu, O., Chanimbe, T., Anaduaka, U. S. 2022, Effect of public health expenditure on health outcomes in Nigeria and Ghana, *Health Policy OPEN*, vol. 3, 100072, https://doi.org/10.1016/j.hpopen.2022.100072

7. Singh, S., Bala, M. M., Kumar, N. 2022, The dynamics of public and private health expenditure on health outcome in Southeast Asia, *Health and Social Care in the Community*, vol. 30, № 5, p. e2549—e2558, https://doi.org/10.1111/hsc.13698

8. Ivankova, V., Gavurova, B., Khouri, S. 2022, Understanding the relationships between health spending, treatable mortality and economic productivity in OECD countries, *Frontiers in Public Health*, vol. 10, p. 1036058, https://doi.org/10.3389/fpubh.2022.1036058

9. Arthur, E., Oaikhenan, H. E. 2017, The effects of health expenditure on health outcomes in Sub-Saharan Africa (SSA), *African Development Review*, vol. 29, № 3, p. 524— 536, https://doi.org/10.1111/1467-8268.12287

10. Akinkugbe, O., Mohanoe, M. 2009, Public health expenditure as a determinant of health status in Lesotho, *Social Work in Public Health*, vol. 24, № 1-2, p. 131—147, https://doi.org/10.1080/19371910802569716

11. Anyanwu, J. C., Erhijakpor, A. E. 2009, Health expenditures and health outcomes in Africa, *African Development Review*, vol. 21, № 2, p. 400—433, https://doi.org/10.1111/j.1467-8268.2009.00215.x

12. Hlafa, B., Sibanda, K., Hompashe, D. M. 2019, The impact of public health expenditure on health outcomes in South Africa, *International Journal of Environmental Research and Public Health,* vol. 16, № 16, p. 2993, https://doi.org/10.3390/ijerph16162993

13. Kumar, K., Ram, F., Singh, A. 2013, Public health spending on infant and child mortality in India during the years 1980—2006, *The Lancet*, vol. 381, p. S76, https://doi.org/10.1016/S0140-6736(13)61330-6

14. Novignon, S., Olakojo, A., Nonvignon, J. 2012, The effects of public and private health care expenditure on health status in sub-Saharan Africa: new evidence from panel data analysis, *Health Economics Review,* vol. 2, № 1, https://doi.org/10.1186/2191-1991-2-22

15. Rahman, M. M., Khanam, R., Rahman, M. 2018, Health care expenditure and health outcome nexus: new evidence from the SAARC-ASEAN region, *Globalization and health*, vol. 14, № 1, https://doi.org/10.1186/s12992-018-0430-1

16. Cheng, Y., Li, S. 2006, Income inequality and efficiency: A decomposition approach and applications to China, *Economics Letters*, vol. 91, №1, p. 8—14, https://doi.org/10.1016/j.econlet.2005.09.011

17. van den Heuvel, Wim, J. A., Olaroiu, M. 2017, How important are healthcare expenditures for life expectancy? A comparative, European Analysis, *Journal of the American Medical Directors,* vol. 18, №3, p. 276.e9—276.e12, https://doi.org/10.1016/j.jamda.2016.11.027

18. Anwar, A., Hyder, S., Mohamed Nor, N., Younis, M. 2023, Government health expenditures and health outcome nexus: A study on OECD countries, *Frontiers in Public Health*, vol. 11, 1123759, https://doi.org/10.3389/fpubh.2023.1123759

19. Roffia, P., Bucciol, A., Hashlamoun, S. 2023 Determinants of life expecatncy at birth: A longitudinal study on OECD countries, *International Journal of Health Economics and Management,* vol. 23, p. 189—212, https://doi.org/10.1007/s10754-022-09338-5

20. Linden, M., Ray, D. 2017, Life expecatncy effects of public and private health expenditures in OECD countries 1970-2012: A panel time series approach, I*nternational Economic Analysis and Policy*, vol. 56, p. 101—113, https://doi.org/10.1016/j.eap.2017.06.005

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DEVELOPMENT STAGES OF ETHNIC CONTACT ZONES IN ESTONIA, LATVIA AND LITHUANIA SINCE THE END OF THE 19th CENTURY

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The analysis of changes in the ethnic structure of the population is one of the most central topics in the study of the development of Estonia, Latvia and Lithuania. This work aims to identify stages in the evolution of ethno-contact zones in the Baltic States, using ethnic statistics from the end of the 19th century to the present. This study employs, for the first time, a methodology for identifying stages of ethnic contact zone development. This methodology simultaneously considers the direction of change in the ethnic mosaic index used to determine the phases of growth and dissolution of ethnic contact zones and the positive or negative dynamics of the proportion of titular ethnic groups. The ethnic mosaic index helped identify five prominent ethnic contact zones: the capitals of the Baltic countries, Ida-Viru County in Estonia and the Latgale region in Latvia. Over the past century and a half, these ethnic contact zones have exhibited three different types of dynamics. The first is characteristic of Tallinn, Riga and the Latgale region, where phases of ethnic contact zone growth and dissolution alternate as the proportion of titular ethnic groups changes in response to the vicissitudes of history. The second is peculiar to the Estonian county of Ida-Virumaa, which has experienced phases of ethnic contact zone development and an increase in the non-titular population. The third, exemplified by Vilnius, combines phases of ethnic contact zone growth and dissolution with a rise in the proportion of the titular ethnic group. The proposed methodology can be extended to the analysis of ethnic contact zone development in other territories as well.

Keywords:
national composition, ethnic mosaic index, monoethnicity, polyethnicity, titular peoples, non-titular population

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Introduction

Changes in the national composition of the population are among the most pressing topics in the study of the modern development of the Baltic countries (Estonia, Latvia, and Lithuania). At the same time, there is interest in studying ethno-demographic processes on their territory over a long time interval. The most significant factor leading to changes in the ethnic structure of the populations of Estonia, Latvia, and Lithuania in the 20th-early 21st centuries was migration. The direction of migration processes has been determined by the political status of the republics. The periods of first and second independence (1920—1940 and since 1991 onwards) were characterized by an increase in the proportion of the titular population of the republics and the Soviet period — by an increase in the share of the non-titular population.

At the same time, the development of ethno-demographic processes exhibited significant territorial differences. On one hand, parts of the republics' territories remained mono-ethnic and were unaffected by migration. On the other hand, zones of intense contact between indigenous and immigrant populations were formed. The formation and development of these ethno-contact zones span a considerable period, often longer than a century. However, statistical analysis of the development of ethnic contact zones has a more limited time interval, since it can only be based on the results of population counts and censuses. This study presents the experience of conducting such an analysis, for which the authors, based on ethnic statistics from 1881 to the present, have developed a methodology for identifying the stages of the development of ethnic contact zones located on the modern territory of Estonia, Latvia, and Lithuania.

It should be noted that the concept of the 'ethnic contact zone' in the study is based on the geospatial approach developed in Russian cultural geography. Ethnic contact zones are considered elements of the territorial structure of the ethnic layer of geocultural space (ethnic space). These zones result from the overlap of two or more ethnic territorial systems. Following this approach, it is possible to identify ethnic contact zones of different hierarchical levels — from civilizational (macro level) to local (micro level).

This article focuses on ethnic contact zones at the regional scale (meso level). The aim is to identify the stages of development of the most pronounced ethnic contact zones in Estonia, Latvia, and Lithuania, using ethnic statistics from the late 19th century to the present.

Degree of knowledge of the problem

The traditional method for studying the development of the national composition of the Baltic population in the 19th century, along with the ethnic structure dynamics of Estonia, Latvia, and Lithuania in the 20th century, involves analy-

zing fluctuations in the size and proportion of major ethnic groups across census years and population records. Notably, comprehensive ethno-demographic analyses based on this approach were conducted by Kazmina [1; 2] and Kabuzan [3]. Since the 1960s, Russian science has increasingly developed indicators to assess the diversity of ethnic structures within populations. Presently, the ethnic mosaic index proposed by Eckel in 1976 [4] is commonly used for this purpose. It is worth noting that the term 'ethnic mosaic index' was previously introduced by Pokshishevsky in 1969 [5]. Initially, various formulas were suggested for calculating the ethnic mosaic of cities and regions, but it was the index introduced by Eckel that made it possible to compare the national composition mosaic of populations across comparable territories [6].

The ethnic mosaic index (EMI) is calculated using the formula

$$\text{EMI} = 1 - \sum_{i=1}^{N} (n_i)^2,$$

where N is the number of nationalities represented in the region and n_i is the share of the *i-th* nationality in the population of a region.

It should be noted that this indicator was first proposed 20 years before Ekkel by Greenberg [7] for studying the linguistic diversity of populations and it was named the 'index of ethnolinguistic fractionalization'. Subsequently, Greenberg had many followers, and this indicator became widely known in international science as the 'ethnic fractionalization index' ([8—11], etc.). This index is most commonly used to explore the relationship between the ethnic diversity of countries and regions and their economic development ([12—14], etc.). Russian economists have also embraced this research topic and use the same terminology for the index as proposed in international science ([15—17], etc.).

This index is now frequently employed in ethnic geography and ethnodemography to analyse the dynamics and complexity of the ethnic structure within populations of countries and regions. A graphical method of displaying changes in an indicator is often used for this. For example, Drazhanova [18] presents the results of calculating the index for 162 countries for a period spanning 1945—2013. Nemeth [19; 20] calculated the value of the index for Latvia from 1897 to 2011. Among domestic studies, one can note, for example, the EMI calculation of Dorofeeva and Savoskul [6] for several regions of Russia based on the results of population censuses between 1959 and 2002. The authors of this article also have experience in calculating EMI for long-time intervals (since the 1897 census) for regions of Central Asia [21] and Crimea [22].

Attempts have also been made to display the dynamics of the index by region of the country using the cartographic research method, for example in the works [20; 23; 24]. The disadvantage of this technique is associated with the need for

developing cartographic material for each time interval. Yet there is also an advantage associated with the ability to identify spatial patterns and features of changes in EMI on the territory of the country.

Materials and methods

The information base for the study is data from censuses and population records in the territories of Estonia, Latvia and Lithuania, posted on the website Population Statistics of Eastern Europe and former USSR.[1]

Based on these statistical data, the Ethnic Mosaic Index (EMI) was calculated for all counties of Estonia, Lithuania, and statistical regions in Latvia for 2021. Additionally, the EMI was computed for five selected regions that represent ethnic contact zones which have existed for over a century: the three capitals of the Baltic states, as well as Latgale in Latvia and Ida-Virumaa in Estonia. These calculations were based on census and population records spanning from 1881 to 2022.

Gorokhov [25] draws attention to two shortcomings of the EMI: 1) the vagueness of the range of values accepted by the indicator; 2) the implicit dependence of the indicator values on the number of nationalities registered in the region. The set of EMI values belongs to the interval from 0 to $1 - 1/N$, where N is the number of nationalities registered in the region. Gorokhov proposes to normalize the EMI by the number of nationalities and thereby bring the set of indicator values to the range from 0 to 1. The author proposed to call such an indicator the 'modified mosaic index' (MMI).

It is calculated as follows: $MMI=EMI/(1 - 1 / N)$.

Due to its unique range of accepted values, the Modified Mosaic Index (MMI) is convenient for comparative analysis. However, its practical application presents challenges that are less common when assessing religious mosaics, where Gorokhov originally proposed the use of MMI. To begin with, it should be noted that in states and their larger regions, representatives of up to a hundred or more nationalities are usually included, resulting in minimal differences between the Ethnic Mosaic Index (EMI) and the Modified Mosaic Index (MMI). At the microregional level, there are challenges due to limited ethnic statistics and the arbitrary selection of nationalities. The limited number of nationalities taken into account has a minor impact on the EMI calculation since larger ethnic groups are always prioritized. However, their number significantly affects the value of the MMI, resulting in 'jumps' when comparing MMI across different years solely due to the number of ethnic groups considered. Therefore, due to the specifics of ethnic statistics at the microregional level, our study uses the EMI instead of the MMI.

[1] Population statistics of Eastern Europe & former USSR, URL: http://pop-stat.mashke.org/ (accessed 26.07.2023).

Garipov [26] notes that a significant drawback of B. M. Ekkel's methodology is that it does not consider the ratio of indigenous to non-indigenous populations within national autonomies. For instance, the IEM (Index of Ethnic Maturity) can have equal values in national regions where the titular population clearly prevails or where the non-titular population numerically predominates. Taking this remark into account, we have proposed a methodology based on the simultaneous analysis of the positive or negative dynamics of the IEM and the proportion of titular ethnic groups in the territories.

The map, which presents the EMI value for the regions of Estonia, Latvia, and Lithuania for 2021, uses the EMI scale, which is most often employed in ethno-geographical studies. The primary thresholds for this gradation are EMI values 0.2 and 0.4. This EMI scale was used, for example, in works [27—30] and others. Formally, territories where the EMI is less than 0.2 can be classified as monoethnic, and those over 0.2 as ethnic contact zones (ECZs). However, due to the considerable number of counties in Estonia and Lithuania with an EMI value of less than 0.2, we proposed introducing an intermediate limit at EMI=0.1. This allows us to distinguish between truly monoethnic territories and counties with a slightly more complex ethnic structure (weakly pronounced ethnic contact zone).

In our study of the dynamics of the Ethnic Mosaic Index (EMI) in long-standing two-component ethnic contact zones (ECZ), we observed a cyclical pattern in their development. This pattern enabled us to identify two primary phases in ECZ evolution, driven by changes in both EMI and the proportions of titular and non-titular populations in national territories. These phases are the growth phase (marked by an increase in EMI) and the dissolution phase (marked by a decrease in EMI). Since ECZ growth can result from increases in either titular or non-titular populations, we proposed distinguishing between 'waves' of titularization (growth in the share of titular ethnic groups) and detitularization (growth in the share of non-titular populations). This identification of phases and 'waves' in ECZ development enabled us to pinpoint the main stages of development for the five ethnic contact zones previously outlined, using a graph of EMI dynamics. As an additional characteristic, the graphs show changes in the proportion of titular peoples to facilitate the task of distinguishing between the waves of titularization and detitularization (before the establishment of republics — waves of indigenization and deindigenization).

Research results and discussion

Figure 1 shows the EMI value for the regions of Estonia, Latvia, and Lithuania according to the results of the 2021 population census. The most ethnically diverse regions in Estonia are Ida-Viru County and the capital of the country Tal-

linn (EMI over 0.4), in Latvia — the Latgale region (Russian name — Latgalia) and the capital of the country Riga (in these two cases EMI exceeds 0.6), in Lithuania — Vilnius and the capital district (EMI over 0.4). These territories represent the most pronounced ethnic contact zones in the three Baltic states, each with a long history of development. Consequently, they were selected for the analysis of the Ethnic Mosaic Index (EMI) dynamics, specifically to highlight the stages of EMI development over a period exceeding a century. Only the capital county of Lithuania was excluded from this analysis due to the instability of the administrative boundaries of this region. Therefore, only the city of Vilnius was selected from Lithuania for the study.

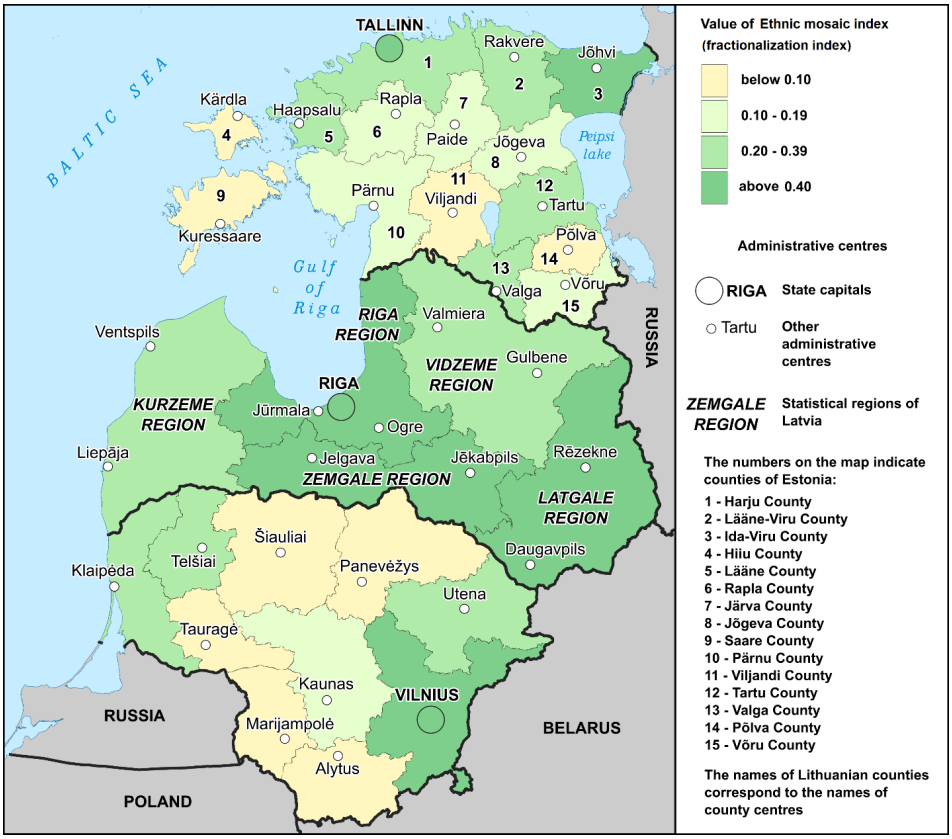

Fig. 1. The value of the ethnic mosaic index by region in Estonia, Latvia and Lithuania based on the results of the 2021 population census

Figure 2 shows the dynamics of the EMI from 1881 to 2022 for the five identified ethnic contact zones, broken down by the stage of development of the ECZ and with an additional characteristic — a change in the share of titular ethnic groups. The most obvious waves of development of ECZ are observed in two ethnic contact zones of Estonia — Tallinn and Ida-Viru County.

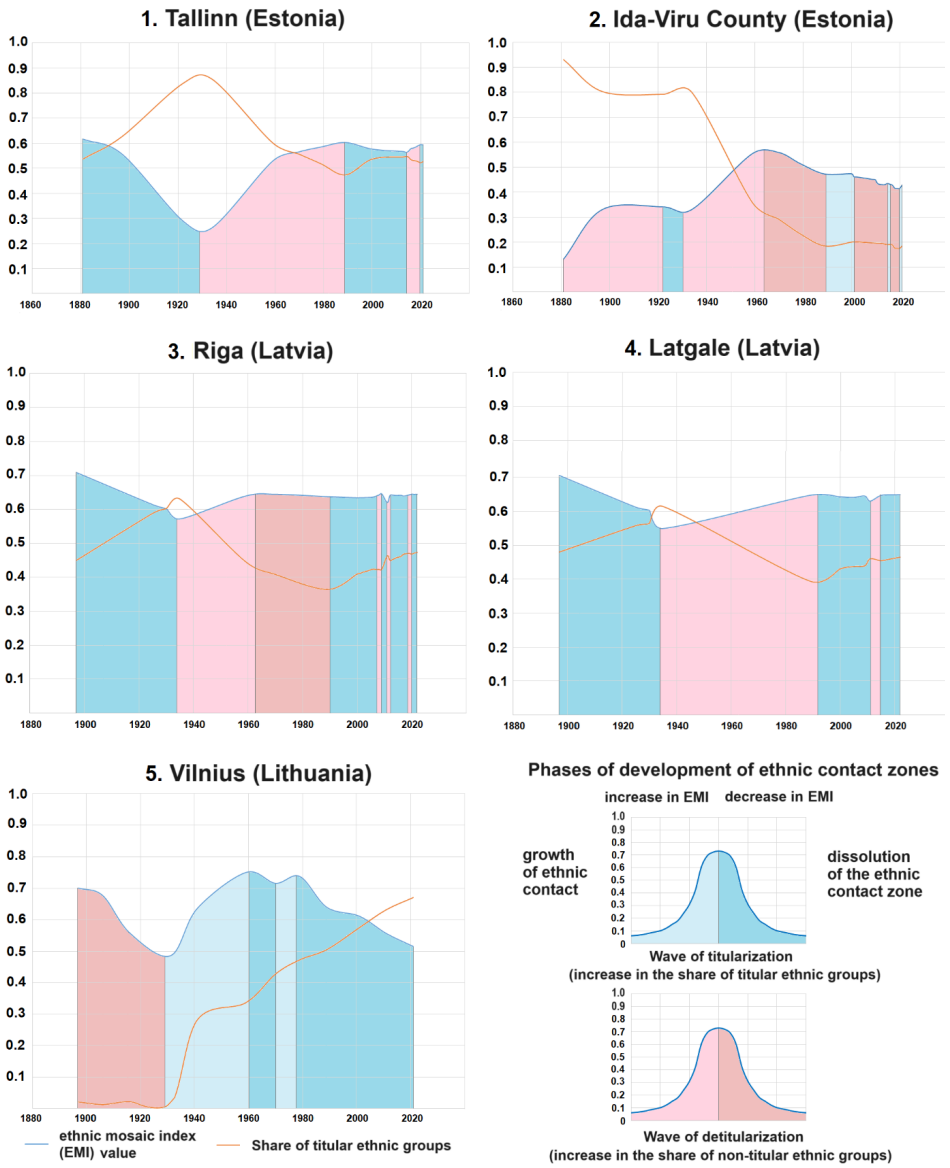

Fig. 2. Dynamics of the ethnic mosaic index from 1881 to 2022 in the five most pronounced ethnic contact zones of Estonia, Latvia, and Lithuania

In Tallinn, up until Estonia's inclusion in the USSR, the share of the titular ethnic group increased, leading to a decrease in the EMI. This period of Tallinn's ethnic history can be characterized as a phase of dissolution of ethnic contact zones during a wave of titularization of the population. Subsequently, up until Estonia regained independence, there was a decrease in the proportion of the Estonian population in Tallinn, leading to an increase in the EMI. This peri-

od can be seen as a phase of growth of ethnic contact zones during a wave of detitularization of the population. In the post-Soviet period, the capital's ethnic contact zones once again entered a phase of dissolution during a wave of titularization. However, this phase was interrupted for a short period (from 2014 to 2020), when the share of Estonians in the capital temporarily decreased. This corresponds to the growth phase of the ECZ during a wave of detitularization of the population. After 2020, Tallinn returned to its usual post-Soviet dynamics of ethnic mosaic.

Ida-Viru County is currently the most Russian-speaking county in Estonia. According to the 2021 population census, Russians accounted for 73.2 % of the population, while Estonians were only 18.4 %. However, in the pre-war period, the proportion of Estonians here exceeded half of the population, albeit with slight growth occurring only during Estonia's first independence period. As a result, until the 1960s, there was predominantly growth of ethnic contact zones during waves of detitularization of the population, with a brief interruption in the 1920s—1930s when a temporary dissolution of ethnic contact zones occurred during a wave of titularization. But since the 1960s, the dissolution of ethnic contact zones has resumed during waves of detitularization. Despite efforts to increase the share of the titular ethnic group in the 1990s and certain years of the 21st century, the dynamics of ethnic contact zones largely persisted in the post-Soviet period, maintaining a trend of titularization-driven growth.

Two ethnic contact zones selected for analysis in Latvia, Riga and Latgale, despite their distinct geographical locations and diverse ethnic compositions, exhibit remarkably similar dynamics. This parallelism is attributed to Riga and Latgale following common trends in Latvia's ethnic mosaic changes, albeit in a moderated manner without abrupt shifts, as noted in Nemeth's research [20]. Prior to Latvia's integration into the Soviet Union, both zones experienced dissolution phases during waves of population titularization. Subsequently, there was a period of growth in these zones during waves of detitularization. They approached the dissolution stage during this phase, but after the demise of the USSR, a wave of titularization reemerged. Currently, the dissolution of these zones is progressing, albeit hesitantly, with brief periods of detitularization observed in the early 21st century. This developmental characteristic during this period can be described as 'phase instability'.

A different dynamic of EMI and the share of the titular population characterizes the capital of Lithuania. In Vilnius, until it received the status of the capital of Lithuania in 1939, the proportion of Lithuanians was extremely low. In the 1920—1930s, the titular population of Vilnius was Poles, and the dissolution of the ECZ during this period was in their favour. It should be noted that some inconsistency between the key dates of political history and the stages of development of the ECZ on the graph is due to the lack of data on the ethnic composition

of the population at these moments and with the forced binding of the EMI to the years of population censuses. But it is obvious that already in the pre-war period in Vilnius, a rapid increase in the proportion of Lithuanians began, and the ECZ entered a growth phase on the wave of titularization, and in the second half of the 20th century it began to dissolve on the same wave.

Thus, based on the analysis of the five examined ECZs, three main types of ECZ dynamics can be distinguished. The first type is typical of the capitals of Estonia and Latvia, as well as the Latvian region of Latgale. In this type, periods of growth and dissolution of the ECZ alternate on the 'waves' of titularization and detitularization of the population, depending on the political history of Estonia and Latvia. The second type of ECZ dynamics is exemplified by Estonia's Ida-Viru County, which experienced both phases of ECZ development during the 'wave' of detitularization of the population. The short-term 'waves' of titularization during periods of Estonian independence did not bring about significant changes. The third type, which includes both phases of ECZ development during waves of titularization of the population, is demonstrated by the capital of Lithuania.

The presented methodology also contains unsolved problems that arose due to the complex nature of the development of multicomponent ECZ. The technique was originally developed for two-component ethnic systems, where the dynamics of the EMI is directly related to changes in the ratio of the relative weight of two ethnic groups. In multicomponent ECZ, a change in the proportion of one of the ethnic groups, even if it is the most numerous, is not the only factor in the dynamics of the EMI, since it is also influenced by a change in the ratio of other ethnic groups. Therefore, the maximum and minimum values of the EMI are not always associated with critical moments in the dynamics of the share of the titular ethnic group (the beginning of an increase or decrease in the share, crossing the line of 50 % of the total population). This scientific problem remains to be solved in subsequent studies. In general, the combination of the proposed methodology of the dynamics of EMI and changes in the proportion of titular peoples provides a new look at ethnic processes in multinational territories, namely, through the prism of the staged development of ethnic contact zones.

Conclusions

During the study using the Ethnic Mosaic Index, five of the most pronounced ethnic contact zones in Estonia, Latvia, and Lithuania were identified, including all Baltic capital cities, as well as Ida-Viru County in Estonia and the Latgale region in Latvia. The prolonged existence of these ethnic contact zones allowed for the identification of development stages spanning over a century. The meth-

odology for identifying these stages of ethnic contact zone development is based on simultaneous consideration of changes in the Ethnic Mosaic Index (phases of growth and dissolution of ECZ) and the positive or negative dynamics of the proportion of titular ethnic groups (waves of titularization and detitularization of the population).

As a result of the analysis, three main types of dynamics of ethnic contact zones were identified. The first type is represented by Tallinn, Riga, and the Latvian region of Latgale. In this type, there are alternating periods of growth and dissolution of ECZ, driven by waves of titularization and detitularization of the population, depending on the political history of the countries. The second type of dynamics was demonstrated by Ida-Viru County in Estonia, which has experienced both phases of development of the ECZ during the wave of detitulisation of the population, which was not reversed by the short-term waves of titulisation during periods of Estonia's independence. The third type of dynamics, represented by Vilnius, includes both phases of ECZ development (growth and dissolution) on a wave of titularization of the population.

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References

1. Kazmina, O. E. 1991, Dynamics of the number of Estonian national groups in the 20th century, *Rasy` i narody`* [Races and peoples], № 21, p. 79—99 (in Russ.).

2. Kazmina, O. E. 1991, Dynamics of the ethnic structure of the population of Latvia in the XX century, *Nacional`ny`e processy` v SSSR* [National processes in the USSR], p. 187—216 (in Russ.).

3. Kabuzan, V. M. 2009, *Formirovanie mnogonacional`nogo naseleniya Pribaltiki (E`stonii, Latvii, Litvy`, Kaliningradskoj oblasti Rossii) v XIX—XX vv. (1795—2000 gg.)* [Formation of the multinational population of the Baltic states (Estonia, Latvia, Lithuania, the Kaliningrad region of Russia) in the 19th—20th centuries (1795—2000)], M., 152 p. (in Russ.).

4. Ekkel, B. M. 1976, Determination of the mosaic index of the national composition of the republics, territories and regions of the USSR, *Sovetskaya etnografiya* [Soviet ethnography], № 2, p. 33—39 (in Russ.).

5. Pokshishevsky, V. V. 1969, Ethnic processes in the cities of the USSR and some problems of their study, *Sovetskaya etnografiya* [Soviet ethnography], № 5, p. 3—15 (in Russ.).

6. Dorofeeva, D. Yu., Savoskul, M. S. 2010, Changing the ethnic mosaic of Russian regions, In: Danilova, I. A., Kharaeva, O. A. (eds.), *Jetnicheskaja demografija. Sbornik statej* [Ethnic demography. Collection. Ser. Demographic Research], M., MAKS Press, p. 72—93. EDN: VLSNND (in Russ.)

7. Greenberg, J.H. 1956, The Measurement of Linguistic Diversity, *Language*, vol. 32, № 1, p. 109—115, https://doi.org/10.2307/410659

8. Montalvo, J.G., Reynal-Querol, M. 2005, Ethnic Diversity and Economic Development, Journal of Development Economics, vol. 76, № 2, p. 293—323, https://doi.org/10.1016/j.jdeveco.2004.01.002

9. Casey, G., Owen, A. 2014, Inequality and fractionalization, *World Development*, vol. 56, p. 32—50, https://doi.org/10.1016/j.worlddev.2013.10.007

10. Fedderke, J., Luiz, J., de Kadt, R. 2008, Using fractionalization indexes: Deriving methodological principles for growth studies from time series evidence, *Social Indicators Research*, vol. 85, p. 257—278, https://doi.org/10.1007/s11205-007-9090-x

11. Awaworyi Churchill, S., Okai, D., Posso, A. 2016, Internet Use and Ethnic Heterogeneity in a Cross-Section of Countries, Economic Papers: A journal of applied economics and policy, vol. 35, № 1, p. 59—72, https://doi.org/10.1111/1759-3441.12125

12. Alesina, A., La Ferrara, E. 2005, Ethnic Diversity and Economic Performance, *Journal of Economic Literature*, vol. 43, № 3, p. 762—800, https://doi.org/10.1257/002205105774431243

13. Campos, N., Saleh, A., Kuzeyev, V. 2011, Dynamic Ethnic Fractionalization and Economic Growth, *Journal of International Trade and Economic*, vol. 20, № 2, p. 129—152, https://doi.org/10.1080/09638199.2011.538218

14. Papyrakis, E., Mo, P.H. 2014, Fractionalization, polarization, and economic growth: identifying the transmission channels, *Economic Inquiry*, vol. 52, p. 1204—1218, https://doi.org/10.1111/ecin.12070

15. Bufetova, A.N., Khrzhanovskaya, A.A., Kolomak, E.A. 2020, Cultural heterogeneity and economic development in Russia, *Journal of Siberian Federal University. Humanities & Social Sciences*, vol. 13, № 4, p. 453—463, https://doi.org/10.17516/1997-1370-0582

16. Vasilyeva, R.I., Rozhina, E.A. 2022, Econometric Modeling of the Impact of Ethnic Diversity on Economic Diversification: Analysis of Russian Regions, *Journal of Applied Economic Research*, vol. 21, № 4, p. 663—684, https://doi.org/10.15826/vestnik.2022.21.4.023

17. Suslov, N.I., Isupova, E.N., Ivanova, A.I. 2022, Ethnic Diversity in Russian Regions and Economic Growth: Theoretical Model and Its Approbation on Panel Data, *Studies on Russian Economic Development*, vol. 33, p. 149—156, https://doi.org/10.1134/S1075700722020149

18. Dražanová, L. 2020, Introducing the Historical Index of Ethnic Fractionalization (HIEF) Dataset: Accounting for Longitudinal Changes in Ethnic Diversity, *Journal of Open Humanities Data*, vol. 6, № 1, https://doi.org/10.5334/johd.16

19. Németh, Á., Šolks, G. 2012, Alteration of the Ethnic Diversity and Ethnic Segregation Index in Latvia During the First and Second Independence Periods, *The Romanian Journal for Baltic and Nordic Studies*, vol. 4, № 1, p. 9—33, https://doi.org/10.53604/rjbns.v4i1_2

20. Németh, Á. 2013, Ethnic diversity and its spatial change in Latvia, 1897—2011, *Post-Soviet Affairs*, vol. 29, № 5, p.404—438, https://doi.org/10.1080/1060586X.2013.807604

21. Manakov, A. G. 2020, Main Trends in the Transformation of the Ethnic Space of the Central Asian Macroregion from 1897 to 2017, *Regional Research of Russia*, vol. 10, p. 574—582, https://doi.org/10.1134/S2079970520040176

22. Manakov, A. G., Vampilova, L. B. 2023, Assessment of the degree of heterogeneity of the ethnic structure of the population of the Crimea from 1897 to 2014, *Pskov Journal of Regional Studies,* vol. 19, №1, p. 113—128, https://doi.org/10.37490/S221979310023933-9 (in Russ.).

23. Manakov, A. G. 2019, Evaluation of changes in the ethnic mosaic of regions of European Russia in periods between the 1897, 1959 and 2010 censuses, *Izvestiya Rossiiskoi akademii nauk. Seriya geograficheskaya*, №2, p. 117—128, https://doi.org/10.31857/S2587-556620192117-128 (in Russ.).

24. Terenina, N. K. 2022, Ethnic contact index as a tool for studying territories with a mixed national composition of the population, *Pskov Journal of Regional Studies*, vol. 18, №1, p. 101—116, https://doi.org/10.37490/S221979310018427-2 (in Russ.).

25. Gorokhov, S. A. 2014, Religious fractionalization as a factor of regional economic development in the modern world, *Vestnik Moskovskogo universiteta. Seriya 5, Geografiya,* №4, p. 56—61 (in Russ.).

26. Garipov, Yu. Z. 2015, About a technique of quantitative measurement of level of interethnic communication, *Review of Economy, the Law and Sociology*, 2015, №3, p. 194—197. EDN: ULQZDT (in Russ.).

27. Lysenko, A. V., Vodopyanova, D. S., Azanov, D. S2011, Ethnic-contact zones of the North Caucasus, *Vestnik Stavropolskogo gosudarstvennogo universiteta*, 2011, №3, p. 165—170. EDN: NYEPIP (in Russ.).

28. Lysenko, A. V., Azanov, D. S., Vodopyanova, D. S. 2013, Ethnocontact zones in system of ethnocultural division into districts of the North Caucasus, *Science. Innovation. Technologies,* №1, p. 130—137. EDN: RTNOIX (in Russ.).

29. Orlov, A. Yu. 2013, Historical and geographical aspects of the transformation of ethnic structure of the Russian Federation's population, *Regional Studies,* №2 (40), p. 120—124. EDN: RBQHMB (in Russ.).

30. Shitikov, F. V. 2015, Geographic specifics of ethno-confessional situation in the republic of Buryatia, *The Bulletin of Irkutsk State University. Series Earth Sciences,* vol. 11, p. 141—148. EDN: TJBBWH (in Russ.).

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FACTORS IN LOCAL GOVERNMENTS' DIGITALISATION IN THE NORTHWESTERN FEDERAL DISTRICT OF RUSSIA: SOCIAL MEDIA REVIEW

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With digital communication becoming a quotidian practice, social media has emerged as a common channel for personal and business communication, utilised by authorities among other actors. This article proposes an approach for measuring a territory's digitalisation by quantifying local governments' presence on social media. The work aims to identify digital underperformers among municipalities of Russia's Northwestern Federal District, drawing on data from the Vkontakte social network. The empirical part of the research utilised data gathered from 2011 to 2022 on the socioeconomic performance and municipal heads of 1,083 settlements and 199 districts. Significant factors influencing municipalities' presence on social media were determined using binary logistic regression, with two clustering results compared to identify the underperforming municipalities. It was concluded that population size, municipal revenues and expenditures, fiscal capacity and average salary are directly proportional to municipal social media presence, and the distance to the regional centre and the status of a district centre are inversely proportional to the study parameter. Age, place of residence and the method of nomination for elections affect the likelihood of a municipal head having a social media account. The findings show that a fourth of the study settlements, most of them located in the Pskov, Novgorod and Vologda regions, need to take measures to develop digital technologies and strengthen their social media presence.

Keywords:
social media, VKontakte, municipalities, settlements, local administrations, binary logistic regression, Northwestern Federal District

Introduction

Social media emerged less than two decades ago but have already become an integral part of our lives. A social media platform is an online software package designed for communication and social networking. Users themselves create

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its content, which consists of posted personal information, messages, comments, audiovisual content, and non-verbal responses to messages [1]. Nowadays, social media are used for both personal and business communication. Smartphone apps make people available 24/7, enabling a high rate of interaction in real time. Authorities are expected to adopt the communication tools that citizens habitually use for person-to-person interactions [2]. Government authorities cannot ignore social media, which have millions of users. According to the study "Digital 2023: The Russian Federation," 73.3 % of the Russian population have accounts on social media. Therefore, pages of governors and mayors, as well as official groups of various ministries, departments, and services, were created on social media to reach out to citizens. In 2020, Regional Management Centres were established nationwide to process citizens' messages and complaints on social media and provide feedback. Since December 1, 2022, maintaining official pages on social media under Russian jurisdiction (VKontakte, Odnoklassniki)[1] has become mandatory for state authorities, local administrations, subordinate agencies, and courts.[2]

The absence of initiative in utilising social media by local authorities in several municipalities before the legislative changes can be attributed to the low level of digitalization. We define the digitalization level of a municipality as the combination of the following factors: the availability of relevant infrastructure for stable internet connection throughout the territory, the possession of and access to necessary equipment among the population, and the financial affordability of internet access. This constraint applied more to rural areas,[3] where the process of adopting social media in the work of local administrations was slow and challenging.

In this article, we propose viewing social media as an indicator of the level of digitalization of a territory. The creation of official social media pages by conservative organisations such as municipal administrations suggests that a significant portion of the local population has access to and actively uses these platforms. This indicates that the territory likely has broadband and/or mobile internet coverage, and its citizens possess the necessary tools and devices to access these platforms.

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[1] Order № 2523-r dated September 2, 2022. *Government of the Russian Federation*. URL: http://government.ru/docs/46448/ (accessed 17.05.2023).

[2] Federal Law of July 14, 2022 № 270 FZ. *Official Internet portal of legal information*. URL: http://actual.pravo.gov.ru/content/content.html#pnum=0001202207140024 (accessed 17.05.2023).

[3] For example, in the annual report 2020, Head of the Krivetsky Rural Settlement (Pudozh District, Republic of Karelia) informs: "Residents of some settlements, namely Prirechny Village and Ust-Reka Village, often criticize the quality of telephone connection (Rostelecom), since there is no other type of communication available. In 2020, work on laying a fiber-optic Internet line to socially significant facilities (school, post office, and medical posts) was completed and the plan is to extend the connection to citizens. The application was submitted this year." Register of regulatory legal acts for the Krivetsky Rural Settlement, March 2021. URL: https://pudogadm.ru/poseleniya/krivetskoe_selskoe_poselenie/normativno-pravovye-akty/reestr-npa-po-kriveckomu-sel-skomu-poseleniju-mart-2021-goda (accessed 09.11.2023).

Our goal was to identify municipalities in the Northwestern Federal District of Russia that perform the worst in using Internet capabilities in the work of local administrations by analysing factors influencing the emergence of official groups on social media (a case study of VKontakte). It is reasonable to assume that if authorities struggle with using social media, they are likely to face difficulties with other applications of digital technologies as well. In the absence of official statistics on the development of information and communication technologies (ICT) at the municipal level in Russia, indirect methods for assessing the level of digitalization seem extremely important and relevant.

Literature review

In recent years, the digital economy has become one of the most popular topics among Russian economists. However, the study of territorial differentiation is mainly limited to the regional level [3—6]. This tendency is not exclusive to Russian researchers. In foreign academic literature, the municipal level is seldom represented due to the lack of publicly accessible specialized databases [7; 8]. The primary solution suggested has been to conduct sociological surveys with large sample sizes [9—11], although this is not always feasible. Another option is to use alternative data sources. Russian researchers use the maps of mobile network operators with Internet coverage areas [3; 12] and metrics that characterize online trading at pickup points [12]. These data are detailed enough to conduct research at the municipal scale. Another possible metric is the assessment of settlements' self-presentation on the Internet using official websites [13]. We could not find any Russian-authored studies that have used municipalities' official groups on social media for these purposes.

The topic of adopting social media to serve government needs came into the focus of scientific attention after the release of the Transparency and Open Government Memorandum on January 21, 2009, in the United States [14]. One of the main research lines is the investigation of the factors contributing to the integration of social media into the work of local administrations and the use of social media by the population for communication with authorities [15—23]. It should be noted that most of the factors studied so far turned out to be insignificant (for example, the level of education [20; 22]). The population size is the only factor that consistently proves significant. The larger the population, the more likely it is for the settlement to have an official page on social media [21] and the higher the administration's activity on social media is [15; 17; 18; 20]. Some of the identified significant factors exhibited opposite effects depending on the study area. Local administrations of financially better-off municipalities are more active on social media and the quality of this activity is higher [16; 18; 20]. At the same time, social media activity in European countries tends to be higher in areas that are less wealthy and less developed in terms of ICT [17]. For instance, in Canada, higher incomes and access to high-speed Internet are indicators that residents pre-

fer to contact local authorities using social media [22]. Conversely, in Spain and Italy, the poorer the population, the more active they are on the local authorities' social media pages [20].

The investigation of the factors promoting the use of social media by public authorities has been largely neglected in Russian research. Russian scientists tend to discuss general issues related to the use of social media in public administration [24; 25] and focus on the relationship between the practice of maintaining official pages of regional heads and the level of public trust in the authorities [26—29]. There seem to be no such studies at the level of districts (okrugs) or settlements, where social media accounts are maintained by the heads themselves rather than by media offices. Thus, the role of social media in liaising between local governance structures and citizens in Russia has remained unexplored in the scientific literature.

Foreign and Russian researchers pay little attention to the social media activities of administration representatives in sparsely populated municipalities, do not include them in population samples, and do not use cartographic methods. Thus, such studies do not view the territory as a single digital space, failing to provide a comprehensive understanding of the digitalization problems at the settlement level. Our approach, on the other hand, involves full coverage of official social media pages of municipal districts, urban and municipal okrugs, and urban and rural settlements in the Northwestern Federal District of Russia (hereinafter referred to as NWFD), thereby filling the gap in the scientific literature on the degree of digitalization at the municipality level and the use of Russian social media in the work of local governments. Furthermore, this approach reveals the factors influencing the creation of local administrations' official groups on social media in Russia.

Data and Methods

Official municipal groups on the social network VKontakte (VK) were selected as the object of the study. It is the most popular social media in Russia[1] and people in the NWFD historically prefer VK to Odnoklassniki.[2] Besides, Odnoklassniki is the least used social media among heads of the Russian Federa-

[1] Digital 2023: The Russian Federation. 2023, *Datareportal*, URL: https://indd.adobe.com/view/052e9750-217c-4b85-b533-c371ad746349 (accessed 11.04.2023).

[2] In 2023, a comparison of VK and Odnoklassniki audiences in the NWFD's regional capitals (10 cities with the largest population were chosen in the Leningrad Region) by the TargetHunter service showed there were, on average, 5.1 pages on VK per one page in Odnoklassniki (Kaliningrad — 9.7; Veliky Novgorod — 6.5; Vologda — 5.7; Arkhangelsk, Murmansk, Petrozavodsk — 5.4; Syktyvkar — 3.9; Pskov — 3.8; Naryan-Mar — 2.3; cities of the Leningrad Region — 2). In St. Petersburg, the number of VK users is 79-fold that of Odnoklassniki. Due to the limitations in the search queries of the TargetHunter service for Odnoklassniki, region-wise comparisons are not possible. Sources: Search. Users. Geolocation. 2024, *TargetHunter*, URL: https://vk.targethunter.ru/search/users/geo (accessed 15.01.2024), Search. Users. Geolocation. 2024, *TargetHunter*, URL: https://ok.targethunter.ru/search/users/geo (accessed 15.01.2024).

tion subjects (regions) [30], which local administrations consult for guidance.[1] Chronologically, the study covers the period from 2011 to 2022. The beginning of this period is characterized by the emergence of the first municipality groups on VK in the NWFD. The geography of the study covers all municipalities of the NWFD excluding St. Petersburg. These are 199 urban and municipal districts,[2] and 1,083 urban and rural settlements.[3] It should be noted that the enlargement of municipal entities was happening during the analysed period, primarily through the formal merging of settlements. Since 2019, it has become common to transform all municipalities within a district into one municipal okrug. In some regions, territorial administrations (Vologda Region) or territorial departments (Arkhangelsk and Novgorod Regions) appeared instead of settlements as entities. The above circumstances made data collection and processing more complicated. Firstly, official statistics for settlements that have become part of municipal okrugs is no longer published. Secondly, the original data had to be recalculated for the enlarged settlements to ensure comparability.

The search for official groups of local administrations on VK was carried out based on the list of municipalities as of the end of 2018.[4] A three-step algorithm was employed for retrieving groups. At the first step, the search was conducted directly on VK using the official name of the municipality. If no group was found, we proceeded to the second step, which involved making a search query in Yandex, for example, 'administration of settlement N on VK' or the official page of settlement N on VK'. Next, we looked for links to social media groups on the official websites of municipalities. If no group was detected after, it was concluded the group did not exist. The description in each group was checked for belonging to the specified region (for districts) and district (for settlements) to avoid errors associated with coincident municipality names.

A convenient feature of Russian social media is that government organisations are marked by a special flag. A vast majority of district groups were also supplied with a special 'tick' denoting an officially verified group. However, this practice was not typical of settlements. The information about VK official groups was collected in January 2023. The date of group creation was recorded as the date of the

[1] As part of our project, we searched for official groups on other social media and found that NWFD municipalities were less represented in Odnoklassniki than on VK. Only 10 official groups were found representing the settlement level.

[2] Some of them have changed their status to municipal okrug.

[3] The number of settlements in NWFD at the end of 2018.

[4] This ensures maximum possible coverage of official groups on VK. While some settlements have changed status to municipal okrugs, their previously created social media groups continue to function as groups of territorial departments.

first post on the wall, rather than the date indicated in the community description because a substantial amount of time could have passed after the page's creation before it started being used for outreach. Moreover, the group could have originally been a closed one and used only for communication between administration employees. The main challenge at this stage was to identify the settlements' official groups. Focusing solely on groups with a 'flag' would be a mistake in our research, since not all the detected groups managed to receive one.[1] Also, some settlements created new groups in 2023 to obtain the status of public organisation. This practice was observed in the Leningrad Region. In such cases, the old groups were considered to accurately determine the start date of social media communication with residents. Unverified groups were included in the study if they lacked advertisements and closely resembled groups with a 'flag' in terms of their group description and the topics of wall posts. Personal pages of municipality heads, groups of local parliament councils, and groups of self-governance entities were not taken into account.

Our approach involves studying the factors influencing digitalization at two levels of administrative-territorial division: districts (okrugs) and settlements.[2] Therefore, the selection of socio-economic indicators was limited by the availability of official statistics for both levels. The empirical basis of the study was the Rosstat database "Indicators of Municipalities". The following information was collected: population size; area of the municipality; number of municipal employees; budget expenses; budget revenues; non-repayable receipts of the budget; and average monthly salary of organisation employees. The latter has not been published for settlements since 2013, so its analogue was calculated based on data from 5-NDFL tax return forms [31]. The shortest road-travel distances from regional[3] and district centres to the settlements were obtained from the Yandex Maps service. There was a plan to use the virtual population (number of users registered on VK) [32] as a factor in addition to the population size, but it was not included in the study as the time series could not be obtained for the years in question.

In addition, an attempt was made to factor in the characteristics of local decision-makers. Information about candidates posted on the website of the Central Election Commission was used to collect facts about heads of municipalities: full name; date of birth; education; place of residence; place of work; job title; and party support for nomination. It should be noted that the choice of the head

[1] Later on, we discovered that groups without a "flag" in January have obtained it by July.

[2] In this group we include municipal districts, and municipal and urban okrugs.

[3] The capital status in the Leningrad Region belonged to different cities over the study period, so St. Petersburg was regarded as the centre.

of a municipality as the decision-maker is suboptimal. A more suitable option to represent executive authorities would be the head of the municipal administration. On the other hand, Russian legislation allows combining these positions in municipalities with a population of less than 1,000 people, which accounts for 38 % of our sample. The absence of a uniform management model across municipalities in the studied area, along with the necessity to consider municipal acts alongside regional legislation, significantly complicates the task of identifying these individuals. A crucial challenge in collecting data on heads of administration stemmed from the lack of a reliable information source. Even compiling retrospective data on heads of municipalities proved to be challenging, as not all municipalities conduct direct elections for this position. In this case, most of the people and the time they served in the office were identified by studying the archive of official municipal websites (service web.archive.org) and local media posts. Still, only information on the current heads could be collected for settlements of the Leningrad Region even using this method.

The significance of the factors was assessed using binary logistic regression, with the dependent variable focusing on the creation of a municipality group on VK rather than its mere existence in the current year. The VK variable is 1 if the group was created in the current year, and 0 in all other cases. This setup implies that when moving to the next year, municipalities that created VK groups in the previous period are excluded from the spatio-temporal data panel. The factor variable 'Region' was introduced to reflect regional characteristics. The 'Year' variable is also a factorial one: it accumulates all institutional changes and events (for example, COVID-19) that changed the attitude towards social media. At the settlement level, the calculations included an additional binary variable *VKd* which accounted for whether the municipal district to which the settlement belonged had a VK group (1 — the group exists, 0 — the group does not exist). If both groups were created within the same year, then the value of *VKd* depended on which group appeared first.

$$\mathrm{VK} = \left\{ \begin{matrix} \text{Socio} - \\ \text{economic} \\ \text{indicators} \end{matrix} \right\} + \left\{ \begin{matrix} \text{Information} \\ \text{about the Head} \end{matrix} \right\} + \text{Year} + \text{Region}$$

The datasets prepared for the calculations for municipal districts and settlements contain a total of 1,373 and 11,562 entries, respectively. For some indicators, not all values could be collected, particularly at the settlement level (Tables 1 and 2). Data on some socio-economic indicators for 2021 and 2022 have not yet been published. Values for some municipalities were missing from the published data. All indicators were converted into comparable values (in 2021 prices) us-

ing regional consumer price indices. The fiscal capacity percentage in Table 1 is defined as the ratio of budget revenues minus non-repayable revenues to budget expenditures. All variables in Table 1, except the distance variables *(Dist, Dist_d, Dist_r),* are anticipated to have a positive effect.

Table 1

Description of socio-economic variables

Variable	Variable description	Time, years	Number of observations	
			Districts	Settlements
Pop	Population size, persons	2011—2021	1.344	10.816
Den	Population density, people per hectare	2011—2021	1.344	8.796
Dist	Distance from the district to the regional centre by road, km	2011—2022	1.352	—
Cent	The settlement is the district centre: 0 — no; 1 — yes	2011—2022	—	11.562
Dist_d	Distance from the settlement to the district centre by road, km	2011—2022	—	11.331
Dist_r	Distance from the settlement to the regional centre by road, km	2011—2022	—	11.331
Sal	Average monthly salary of employees, RUR	2013—2021	1.086	—
Sal_t	Average monthly salary of organization employees based on individual income tax return (5-NDFL), RUR	2015—2021[1]	—	6.362
Rev	Local budget revenues incurred, thousand RUR	2011—2020	1.286	10.077
Exp	Local budget expenses incurred, thousand RUR	2011—2020	1.287	10.073
Ind	Fiscal capacity percentage	2011—2020	1.286	9.978
Civ	Number of municipal employees, persons	2011—2021	1.333	9.549

Data sources: the Rosstat "Indicators of municipalities" database,[2] the Federal Tax Service[3] and Yandex Maps.[4]

[1] It was not possible to collect data for the Pskov region for the year 2021 since the Federal Tax Service website duplicates the individual income tax returns (5-NDFL) for 2020 instead.

[2] Database "Indicators of municipalities". 2023, *Rosstat*. URL: https://rosstat.gov.ru/storage/mediabank/munst.htm (accessed 11.02.2023).

[3] Regional tax reports. 2023, *Federal Tax Service*. URL: https://www.nalog.gov.ru/rn10/related_activities/statistics_and_analytics/forms/ (accessed 15.01.2023).

[4] Yandex maps. 2023, *Yandex*. URL: https://yandex.ru/maps (accessed 05.03.2023).

Table 2

Description of variables by heads of municipalities

Variable	Variable description	Number of observations	
		Districts	Settlements
Age	Age,	1.373	9.941
Gender	Sex: male — 0; female — 1	1.373	9.993
Location	Place of residence before appointment to the office: local — 0; newcomer — 1	1.363	9.941
Education	Level of education: higher; vocational; secondary	1.372	9.993
Experience	Previous work experience at the Administration: no — 0; yes — 1	1.373	9.993
Novice	First-time head of municipality: no — 0; yes — 1	1.373	9.993
Party	Party support provided in the direct election for the Head or elections of the local parliament council: United Russia; Communist Party of the Russian Federation; LDPR; Patriots of Russia; A Just Russia; Yabloko; Self-nomination	1.343	9.887
Self-promotion	Ran for office as a self-nominated candidate: no — 0; yes — 1	1.343	9.887

Data source: Central Election Commission of the Russian Federation.[1]

Table 2 presents the variables related to the personal details of the municipality heads. The *Age* variable is expected to have a negative correlation: the younger the head, the higher the chances of a group emergence on VK. Higher education would increase the chances of using social media. Although 61 % of the VK audience are women, the ratio of male and female profiles in regions of the NWFD is currently 49 % versus 51 %,[2] and in 2015 it was 53 % versus 47 %.[3] Therefore, we do not expect the *Gender* variable to have any effect. In addition

[1] Elections' calendar. 2023, *Central Election Commission of the Russian Federation*, URL: http://www.vybory.izbirkom.ru/region/izbirkom (accessed 02.02.2023).

[2] According to the TargetHunter service at the end of 2023.

[3] Male regions. Virtual population of Russia. URL: http://webcensus.ru/vmap/sex-and-age (accessed 01.16.2024).

to the standard characteristics used in such studies (gender, age, party support) [19; 21], an attempt was made to test the 'novice' effect, which could change the established management practices. In a generalized form, the *Novice* variable was used to characterize the change of leadership in the municipality and the first year of the new head in the office. The initial idea was to assess the impact of the duration of the head's holding the office. However, the information available on the website of the Central Election Commission is bound by 2006, which is not enough for this task. The *Experience* and *Location* variables reveal other possible factors that increase the likelihood of using social media when heads are changed. The first one represents the experience of working in the administration of any municipal entity. Not only the place of work but also the position was taken into account.[1] The assumption was that people without such experience were more likely to use social media more actively since they do not have the habit of strictly following the protocol. The second variable was based on the place of residence, with the heads divided into local residents registered in the municipality[2] and newcomers from elsewhere. The newcomer head might bring over the methods of communication that were common where he/she came from but novel for the given municipality. In addition, social media could be a quick and easy way for the new head to present oneself to the entire population and inform about the first results of the work.

The above variables were entered one by one into the binary logistic regression formula containing the year factor. Some socio-economic variables were used in the models in both raw and logarithmic form. The significant variables were selected and new models were built based on their combination. The main task in that stage was to test the stability of the selected factors' impact. The separate district (okrug) and settlement subsets were clustered based on selected socio-economic variables using the k-means clustering method in the R software environment. Before clustering, a multicollinearity test was conducted to exclude some variables from the clustering criteria. The number of clusters was determined using the elbow method, which is implemented in the R factorextra package. Municipalities that underutilize Internet opportunities in municipal government were identified by comparing district and settlement clusters.

[1] Categories of administration employees such as drivers or cleaners were marked as having no work experience.

[2] Settlement heads were regarded to be local if they lived in the municipal district the settlement belonged to.

Results

By 1st February 2023, all municipal districts (okrugs) and urban okrugs in the NWFD except Novaya Zemlya have created official groups on VK. Primacy belongs to ZATO Mirny of the Arkhangelsk Region.[1] Their group appeared on 30th June 2011. Two more municipalities created their groups by the end of 2011. More than a half of the official communities in this category were created between 2017 and 2018 (Fig. 1).

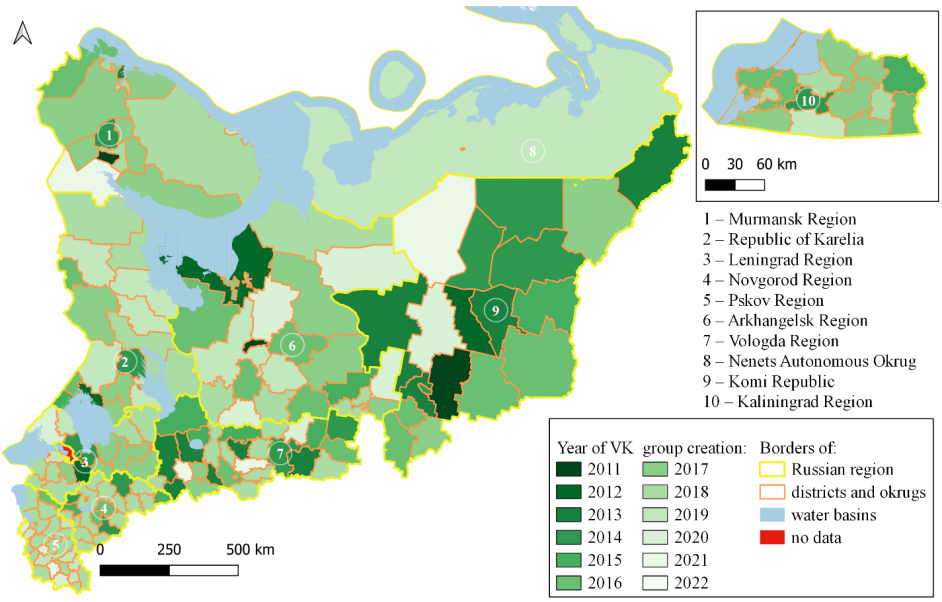

Fig. 1. A retrospective map of district-level VK group creation in the NWFD, 2011—2021

Prepared by authors using VK data.[2]

It is worth noting that the capitals were not pioneers in this process in any of the NWFD regions. The regional centres created their official VK groups two to seven years later than the first municipality from their territory did. At the settlement level, only 65 % of the entities were represented on VK. This percentage varied among regions: from 44.9 % in the Republic of Karelia to 100 % in the Nenets Autonomous Okrug (Table 3).

[1] Based on the date of the first post on the wall, according to our chosen method.

[2] Search of groups, 2023, *Vkontakte*, URL: https://vk.com/groups?act=catalog (accessed 05.01.2023).

Table 3

Settlements on VK in NWFD regions as of 01.02.2023[1]

Region	Number of settlements	Percentage of settlements with VK groups
Nenets Autonomous Okrug	19	100
Komi Republic	159	91.2
Leningrad Region	187	89.8
Murmansk Region	23	69.6
Arkhangelsk Region	178	55.6
Vologda Region	179	55.3
Novgorod Region	120	52.5
Pskov Region	111	45.9
Republic of Karelia	107	44.9

Prepared by authors using VK data[2] and Rosstat.[3]

In this category of municipalities, the process of creating their official groups also started in 2011 and until 2016 less than two dozen of them appeared annually. The average annual number of new groups appearing in the period from 2018 to 2020 was 76. In 2021 and 2022, the number of settlements' official groups on VK increased 2.2-fold. The most significant increase was observed in 2022, with the creation of pages for 248 settlements on VK. Specifically, the Pskov region saw a notable rise, with 43 new settlement groups emerging compared to only nine previously. Another feature of this category of municipal entities was that some district centres had no pages of their own. They were supposed to have acted as a foothold and role model for 'connecting' other settlements in the district to social media, since they have greater resources, including the possibility to delegate this function to a specialist. However, the current practice of merging the administrations of the district and the district centre into one has led to a situation where the joint administration would usually maintain only the district's official page. It is the most vivid in the Leningrad Region (Fig. 2), where only one district centre has a VK group. Meanwhile, almost all non-central settlements in the region have official groups.

[1] At present, the Kaliningrad Region administratively consists entirely of municipal and urban okrugs with no settlements as administrative entities.

[2] Search of groups, 2023, *Vkontakte*, URL: https://vk.com/groups?act=catalog (accessed 05.01.2023).

[3] Number of municipalities by constituent entities of the Russian Federation by 1st January 2023. 2023, *Rosstat*, URL: https://rosstat.gov.ru/storage/mediabank/1-adm-2023.xlsx (accessed 23.04.2023)

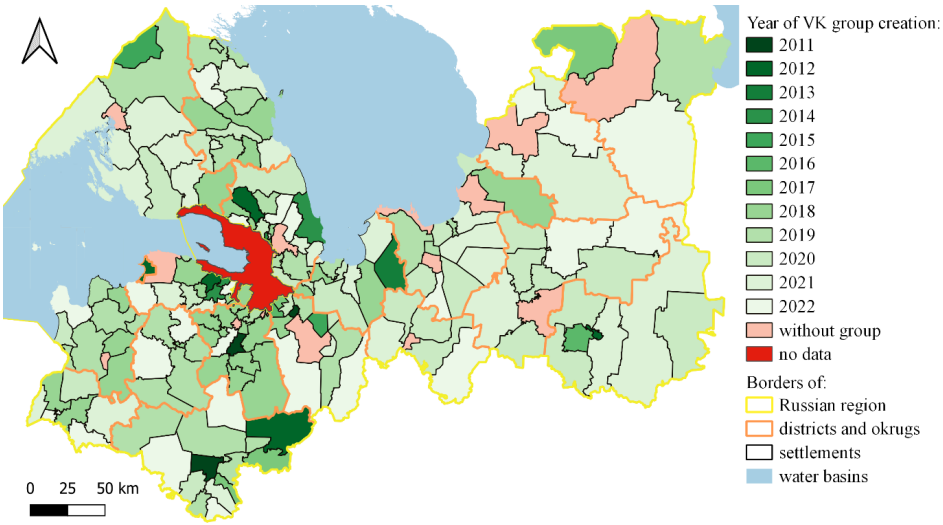

Fig. 2. A retrospective map of VK group creation in the Leningrad Region, 2011—2022

Prepared by authors using VK data.[1]

The binary logistic regression calculations based on the data from districts and okrugs (Table 4) revealed the significance of the population factor, the fiscal capacity, the budget revenues and expenditures: the higher the values of these factors, the higher the rate of official page creation on VK. In addition, the influence of the municipality head on the process was confirmed. If the elected head of the municipality was a non-local or self-nominee as a candidate, the probability of an official VK group being created increased. In the models, the year variable almost always had a significant effect, except in 2012. The likelihood of the VK group being created increased towards 2023. The peak in 2018 is due to the targeted efforts of regional authorities in the Pskov and Novgorod Regions, where VK groups were created almost simultaneously throughout the region. The high values in 2020 and 2021 can be interpreted as a response to the COVID-19 pandemic, as well as an outcome of the activities of the Regional Management Centres and their aspiration to fill in all the 'blank spots'. The combined analysis of these factors proved their impact to be stable (models 7 and 8 from Table 4). Belonging to a specific region and other factors from Tables 1 and 2 turned out to be insignificant.

At the settlement level, analysis confirmed the significance of the factors of population size, average monthly salary of organization employees according to individual income tax returns (5-NDFL), budget revenues and expenditures, the number of municipal employees, distance to the regional centre, district centre status, and the head's age (Table 5).

[1] Search of groups, 2023, *Vkontakte*, URL: https://vk.com/groups?act=catalog (accessed 05.01.2023).

Table 4

Binary logistic regression calculation results for municipal districts (okrugs) and urban districts in the NWFD, 2011—2021[1]

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Intercept term	−6.541***	−4.719***	−8.250***	−8.141***	−4.250***	−4.688***	−4.785***	−7.449***
Year 2012	1.133	1.128	1.142	1.140	0.724	1.116	1.129	1.806’
Year 2013	1.809*	1.773*	1.782*	1.775*	1.486*	1.817*	1.775*	2.435*
Year 2014	2.136**	2.095**	2.125**	2.120*	1.616*	2.149**	1.987*	2.769**
Year 2015	1.977*	1.915*	2.044**	2.044**	1.514*	1.979*	1.875*	2.682*
Year 2016	2.660***	2.570***	2.706***	2.698***	2.186***	2.587***	2.522***	3.290**
Year 2017	3.475***	3.405***	3.544***	3.537***	3.034***	3.499***	3.369***	4.190***
Year 2018	5.267***	5.164***	5.354***	5.347***	4.816***	5.289***	5.160***	6.060***
Year 2019	4.819***	4.729***	4.885***	4.878***	4.363***	4.736***	4.734***	5.543***
Year 2020	5.174***	5.243***	5.416***	5.411***	4.761***	5.093***	5.308***	5.978***
Year 2021	6.303***	—	—	—	5.859***	6.297***	—	7.218***
Log Pop	0.194*	—	—	—	—	—	—	0.193*
Ind	—	0.006*	—	—	—	—	0.006*	—
Log Rev	—	—	0.261**	—	—	—	—	—
Log Exp	—	—	—	0.254**	—	—	—	—
Location	—	—	—	—	0.535*	—	0.516*	0.535*
Self-promotion	—	—	—	—	—	0.427’	—	0.619*
AIC	824.39	782.12	778.01	778.87	836.15	802.94	774.21	769.69
Number of observations	1344	1286	1286	1287	1362	1342	1276	1304
Significance level: ’ p<0.1; * p < 0.05; ** p < 0.01; *** p < 0.001.								

Data source: Tables 1 and 2.

[1] 2022 not included since only the Novaya Zemlya Urban District still had no group on VK.

Table 5

Results of binary logistic regression calculations for settlements in NWFD, 2011—2022

Variables	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14	Model 15	Model 16	Model 17	Model 18	Model 19
Intercept term	−4.586***	−5.630***	−7.568***	−9.192***	−9.228***	−4.549***	−9.288***	−6.204***	−5.426***	−4.490***	−5.057***
Year 2012	0.411	0.411	0.416	0.452	0.459	—	—	0.237***	0.412	0.412	−0.061
Year 2013	−0.685	−0.685	−0.677	−0.652	−0.643	—	***	−0.582	−0.685	−0.684	−0.759
Year 2014	1.410*	1.344*	1.357*	1.341*	1.342*	—	—	1.652**	1.275*	1.275*	1.667*
Year 2015	1.289*	1.287*	1.306*	1.398*	1.388*	—	—	1.669**	1.288*	1.290*	1.762*
Year 2016	1.665**	1.665**	1.690**	1.817**	1.809**	0.377	0.374	1.891**	1.613**	1.616**	2.247**
Year 2017	2.102***	2.100***	2.130***	2.249***	2.249***	0.812*	0.810*	2.389***	2.100***	2.105***	2.593***
Year 2018	3.156***	3.147***	3.195***	3.310***	3.314***	1.848***	1.830***	3.466***	3.140***	3.151***	3.302***
Year 2019	3.101***	3.098***	3.157***	3.257***	3.255***	1.820***	1.801***	3.463***	3.099***	3.113***	3.213***
Year 2020	3.353***	3.397***	3.476***	3.520***	3.519***	2.070***	2.036***	3.804***	3.338***	3.355***	3.794***
Year 2021	4.146***	4.170***	4.262***	—	—	3.009***	2.971***	4.689***	4.130***	4.154***	4.585***
Year 2022	5.243***	—	—	—	—	—	—	—	5.120***	5.147***	5.707***
Cent	−0.932***	—	—	—	—	—	—	—	—	—	—
Pop	—	0.000008’	—	—	—	—	—	—	—	—	—
Log Pop	—	—	0.255***	—	—	—	—	—	—	—	—
Log Rev	—	—	—	0.345***	—	—	—	—	—	—	—
Log Exp	—	—	—	—	0.349***	—	—	—	—	—	—
Sal_t	—	—	—	—	—	0.00001*	-	—	—	—	—
Log Sal_t	—	—	—	—	—	—	0.496**	—	—	—	—
Civ	—	—	—	—	—	—	—	0.069***	—	—	—
Dist_r	—	—	—	—	—	—	—	—	−0.0007**	—	—
Log Dist_r	—	—	—	—	—	—	—	—	—	-0.218***	—
Age	—	—	—	—	—	—	—	—	—	—	−0.020***
AIC	4049	3198.4	3161.3	2442.7	2441.3	2808.5	2801.9	2721.7	4011.7	3997.3	3530.5
Number of observations	11 538	10 816	10 816	10 070	10 073	6362	6362	9549	11 331	11 331	9941
Significance level: ’ p < 0.1; * p < 0.05; ** p < 0.01; *** p < 0.001.											

Data source: Tables 1 and 2.

Contrary to expectations, the district centre status reduced the likelihood of the settlement creating a VK group. The reason for that is the above-mentioned practice of merging district and settlement administrations. Other factors behaved as predicted: higher budget revenues and expenditures, population size, number of municipal employees and average wages increased the likelihood of a group being created on VK. The probability of a settlement creating its official VK group decreased with the distance to the regional centre. Unlike the case of district heads, the only significant characteristic of settlement heads was age. The chance of an official page being created was higher in settlements with younger leaders. The year variable had a significant effect in most cases. Since 2014, a clear trend has emerged towards an increase in settlement page emergence on VK. The most powerful incentive during the study period however was the change in Russian legislation in 2022. Settlements in the Leningrad Region, Komi Republic and the Nenets Autonomous Okrug were more likely to appear on VK compared to settlements in the Pskov Region. The effect of belonging to the rest of the regions proved to be insignificant. For settlements, the fiscal capacity level turned out to be insignificant since it can vary greatly over the years. The fact that the attributes 'distance to the district centre' and 'district's group on VK in place' (*VKd*) had no effect indicates a lack of smooth interaction on social media issues between district and settlement authorities.

Additional models were constructed to combine the significant variables, excluding those that were highly correlated (such as budget revenues, budget expenditures, population size, and number of municipal employees). These models demonstrated both the stability of the impact vector of the selected factors and their significance (Table 6).

For municipal districts (okrugs) and urban districts, clustering was carried out by population size for 2021 and the average fiscal capacity level for 2015—2020. Eleven municipalities were excluded from the clustering due to data gaps. The remaining ones formed four groups (Fig. 3).

The smallest cluster was D4, which included the Nenets Autonomous Okrug and Novaya Zemlya. They are the most hard-to-access and sparsely populated territories with the highest levels of fiscal capacity (Table 7). The next cluster in the order of increasing number of members is D2. It includes all the most populated municipalities: regional centres (except Naryan-Mar); Cherepovets and Severodvinsk urban okrugs; and three municipal districts of the Leningrad Region. The remaining municipalities form two large groups. When comparing the clustering features between them, cluster D3 completely outranks D1. In fact, cluster D1 consists of the economically weakest municipalities. It would be incorrect to say that official pages on VK were being created at a faster rate in any specific cluster. Members of cluster D2 were the first to complete this task, with the last group registered in 2020. In clusters D1 and D3, this process was completed a year later. Before 2018, when the federal government started paying much attention to this matter, the process of creating groups had been more active in cluster D3 than in D1.

Table 6

Results of binary logistic regression calculations for settlements in the NWFD: several variables and the year factor, 2011—22022.

Variables	Model 20	Model 21	Model 22	Model 23	Model 24	Model 25	Model 26	Model 27	Model 28	Model 29	Model 30
Intercept term	−5.092***	−8.740***	−10.705***	−10.662***	−3.826***	−3.799***	−8.845***	−8.643***	−10.974***	−5.538***	−4.054***
Year 2012	−0.060	−0.039	0.062	0.073	—	—	—	—	—	−0.161	−0.054
Year 2013	−0.756	−0.731	−0.658	−0.645	—	—	—	—	—	−0.786	−0.752
Year 2014	1.669*	1.708*	1.666*	1.671*	—	—	—	—	—	1.803*	1.577*
Year 2015	1.764*	1.813*	2.020**	2.003**	—	—	—	—	—	2.006**	1.767*
Year 2016	2.248**	2.312**	2.596***	2.576***	0.478*	0.479	0.473	0.475	0.491	2.348**	2.197**
Year 2017	2.596***	2.672***	2.939***	2.942***	0.824***	0.826*	0.818*	0.821*	0.852*	2.696***	2.602***
Year 2018	3.287***	3.415***	3.634***	3.642***	1.510***	1.496***	1.485***	1.472***	1.568***	3.408***	3.296***
Year 2019	3.201***	3.272***	3.362***	3.359***	1.433***	1.427***	1.402***	1.397***	1.432***	3.270***	3.216***
Year 2020	3.841***	3.955***	3.972***	3.970***	2.024***	2.026***	1.978***	1.981***	2.074***	3.987***	3.795***
Year 2021	4.626***	4.775***	—	—	2.964***	2.967***	2.914***	2.919***	3.080***	4.832***	4.612***
Year 2022	—	—	—	—	—	—	—	—	—	—	5.695***
Cent	−0.989***	−1.749***	−1.524***	−1.525***	−0.683***	−0.992***	−0.727**	−1.024***	−1.857***	−0.758**	−0.844***
Pop	0.000024**	—	—	—	—	0.000021*	—	0.00002*	—	—	—
Log Pop	—	0.525***	—	—	—	—	—	—	0.533***	—	—
Log Rev	—	—	0.560***	—	—	—	—	—	—	—	—
Log Exp	—	—	—	0.561***	—	—	—	—	—	—	—
Sal_t	—	—	—	—	0.000010*	0.000010’	—	—	—	—	—
Log Sal_t	—	—	—	—	—	—	0.524**	0.505**	0.374*	—	—
Civ	—	—	—	—	—	—	—	—	—	0.114***	—
Log Dist_r	—	—	—	—	—	—	—	—	—	—	−0.176***
Age	−0.019**	−0.022***	−0.017*	−0.017*	−0.013*	−0.014*	−0.012*	−0.0134*	−0.017**	−0.0194**	−0.020***
AIC	2629.6	2566.5	1906.2	1905.4	2381	2370.9	2374.7	2364.9	2301.9	2209.5	3417.9
Number of observations	9203	9203	8478	8480	5596	5591	5596	5591	5591	8060	9713
Significance level: ’ p < 0.1; * p < 0.05; ** p < 0.01; *** p < 0.001.											

Data source: Tables 1 and 2.

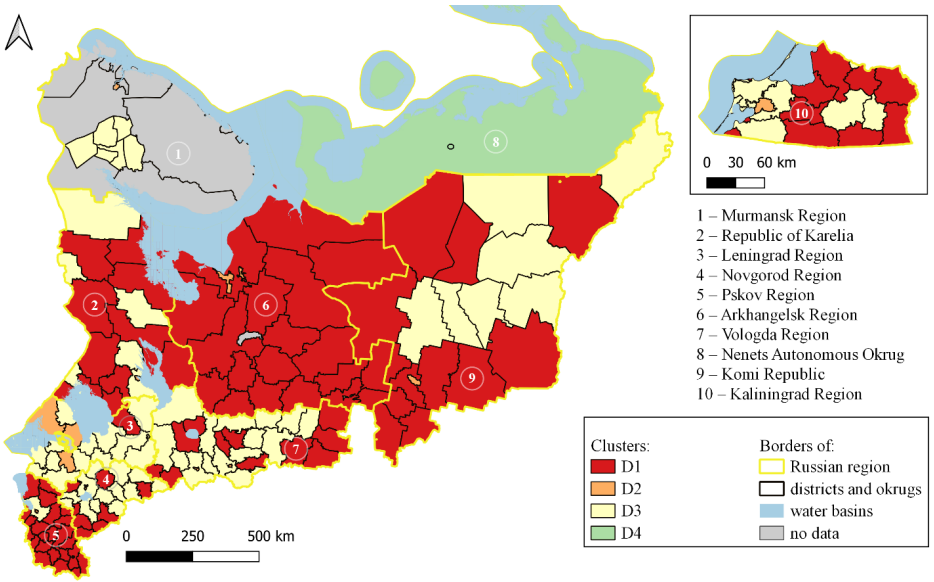

Fig. 3. Clusters of municipal and urban districts (okrugs), 2021

Calculated by the authors using Table 1.

Table 7

Descriptive statistics of cluster groups by municipal and urban districts (okrugs)

Cluster	Number of municipal entities	Indicators	Average	Median	Minimum	Maximum
D1	96	Population size, persons	1,4631.1	1,2970.5	3,551.0	52,192.0
		Budgetary independence, %	23.0	23.7	11.3	31.8
D2	13	Population size, persons	29,4905.4	279,064.0	180,668.0	506,289.0
		Budgetary independence, %	42.9	39.3	31.5	58.5
D3	76	Population size, persons	38,763.2	33,966.5	6,636.0	120,734.0
		Budgetary independence, %	37.6	36.5	26.2	55.6
D4	3	Population size, persons	16,070.7	18,745.0	3,672.0	25,795.0
		Budgetary independence, %	81.7	79.7	74.2	91.1

Calculated by authors using Table 1.

At the settlement level, the population size, average salary, distance to the regional centre, and the district centre status were selected as the clustering criteria. To conduct the cluster analysis, 96 settlements had to be excluded due to missing data. The Kaliningrad Region was also excluded because in 2018 it consisted entirely of urban okrugs and data about settlements was missing. Here, too, four clusters were formed (Fig. 4).

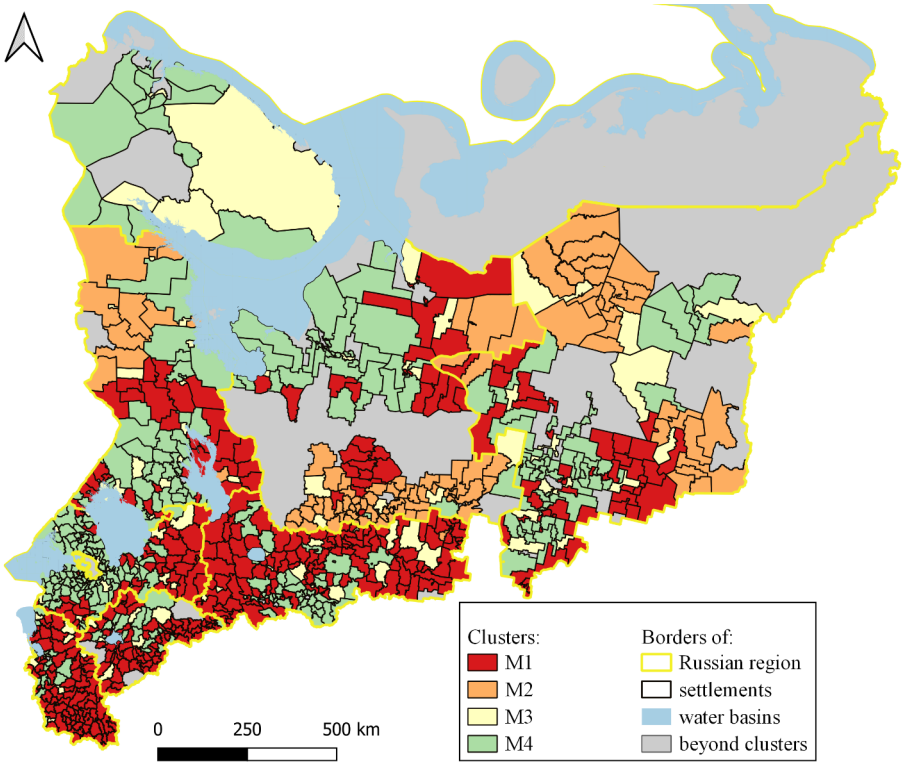

Fig. 4. Clusters of settlements, 2021

Calculated by authors using Table 1.

The settlement cluster with the smallest proportion of VK groups is M3 (Table 8). It includes all district centres of the NWFD and several settlements in the Vsevolozhsk District (Leningrad Region) falling under the strong agglomeration impact of St. Petersburg. A distinctive feature of this cluster is its high population size. It is obvious that had local government optimisation not happened, an overwhelming majority of the cluster's members would have been represented on VK. Cluster M4 has the largest percentage of settlements with official pages on VK. Its members have the highest average salaries and the largest population among non-district-cents. Settlements of the M4 cluster are located in relative proximity to the regional centre — the distance by road from half of them is less

than 100 km. In the M2 cluster, more than 70 % of settlements have VK groups. An average member of this cluster is a settlement located the farthest from the regional centre, sparsely populated, with medium-level incomes. The largest cluster is M1, where 63 % of settlements are represented on VK, and a significant part of them created an official page in 2021 or 2022. This cluster contains sparsely populated settlements with low salaries and a medium distance from the regional centre. Based on our calculations, this combination of factors did not favour the emergence of the settlement's group on VK.

Table 8

Descriptive statistics of settlement clusters

Cluster	Number of settlements	% of settlements with a VK group	Indicator	Average	Median	Minimum	Maximum
M1			Population size, people	1294.2	992.5	80	6198
			Distance to the regional centre, km	221.2	211	9	580
	404	63.4	Average monthly salary of employees of organisations based on income tax returns (5-NDFL), RUR	19 254.0	18 995.8	9327.6	30 006.5
M2			Population size, people	1084.8	703.5	75	4550
			Distance to the regional centre, km	588.6	585	390	890
	98	71.4	Average monthly salary of employees of organisations based on income tax returns (5-NDFL), RUR	27 561.7	26 815.8	20 524.9	38 826.4
M3			Population size, people	15 051.1	8009	1973	90 571
			Distance to the regional centre, km	215.9	178	8	808
	127	41.7	Average monthly salary of employees of organisations based on income tax returns (5-NDFL), RUR	28 586.9	28 379.8	16 268.5	49 773.9
M4			Population size, people	3941.3	2116	85	31127
			Distance to the regional centre, km	127.2	96.5	6	740
	358	79.3	Average monthly salary of employees of organisations based on income tax returns (5-NDFL), RUR	30 701.8	28 246.9	19 232.6	72 463.3

Calculated by authors using Table 1.

A comparison between clusters D1 and M1 revealed the settlements that are less active in using the Internet in municipal government (Fig. 5). Among the 404 settlements in cluster M1, 242 are part of municipal districts from cluster D1. The greatest numbers of such settlements are found in the Komi Republic (47), Pskov (68) and Vologda (51) Regions.

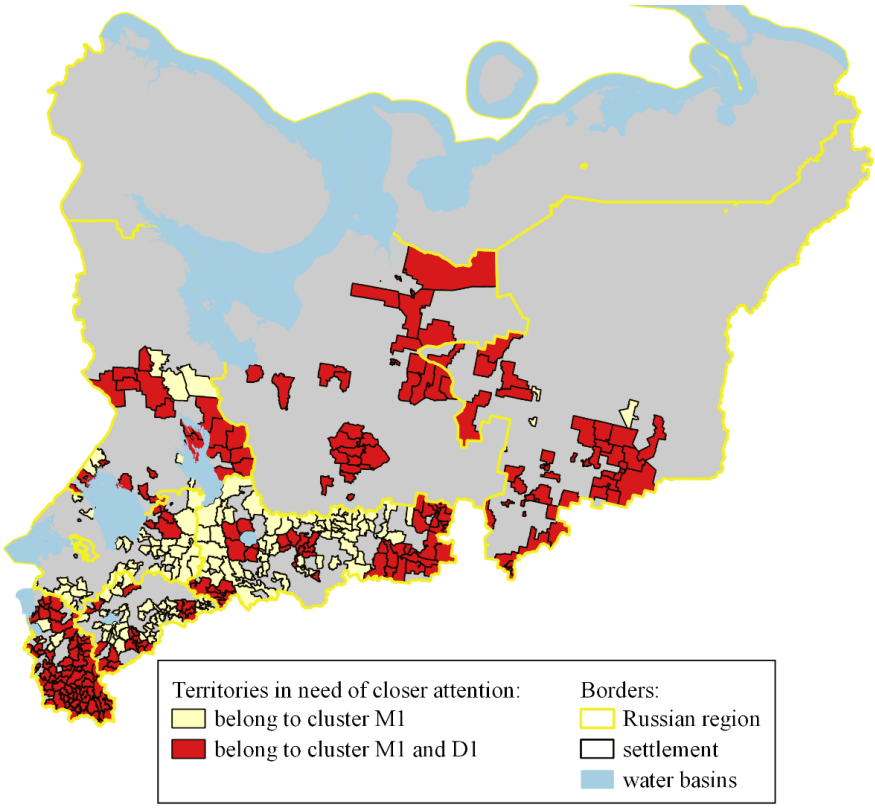

Fig. 5. Potentially hard-to-digitalize settlements

Calculated by authors using Figures 3 and 4.

Discussion and conclusions

Our results show that the engagement of social media in the work of local administrations proceeded at different rates at the administrative division levels in question. The district level is four years ahead of the settlement level. This is largely due to the regional authorities paying greater attention to districts (okrugs). Despite the legislative requirements, more than 30 % of settlements are not represented on VK.[1] One must not ignore the heterogeneity of the 'lag-

[1] 74 out of 124 district centres fall in cluster M3.

gards' group. Firstly, there are the district centres, in which the joint administration maintains only the official page of the municipal district. We believe it is a serious mistake, since the problems, events and matters of concern for residents of the district and the district centre may differ significantly. Thus, rural residents of the district can hardly benefit from the information about the dates on which the town will have no hot water in summer, whereas residents of the district centre are not interested in the information about the mobile dentist's route and schedule for small communities. Furthermore, the district centre can generate many news hooks, so some central messages may not be published on the common page for the sake of balance between centre and district messages. As a result, the interests of the district centre residents get dissolved in the district's current agenda, affecting the communication between the local authorities and citizens[1]. Secondly, this group comprises settlements merged into municipal okrugs. Formally, the legal requirements regarding presence on social media do not apply to them. There, official pages of territorial departments or directorates are maintained instead of settlement groups, depending on the region. This practice can only be welcomed. However, in the absence of uniform standards and rules, this practice is not universal and there is a tendency to minimize the number of groups.

The group of factors with positive effects on the creation of official VK groups includes the population size, income size, and budget expenditures. The population density, however, was insignificant at both levels. The fiscal capacity proved to be significant for districts and okrugs, whereas the average salary level was significant for settlements. Both indicators are metrics of the activity of the local economy. Thus, there is a direct correlation between the successful economic development of the territory and the presence of an official page on social media in the Northwestern Federal District. The distance factor appeared to be significant only at the settlement level. Settlements farther from the regional centre were less likely to create a group on VK. The distance to the district centre had no effect on the settlement's presence on social media, and neither was it influenced by whether the district had its official VK group. The above facts suggest that district authorities are not actively involved in managing the process of introducing social media into the work of settlement administrations.

[1] For example, the City of Vyborg with a population of more than 71 thousand people (36.7 % of the entire district) does not have an official group on VK. The official group of the Vyborg Region has more than 7000 subscribers, while the unofficial groups about events in Vyborg ("Vyborg VKontakte" and "Interesting events in Vyborg") have 64 and 82 thousand subscribers, respectively.

As a result, the regional centre has to orchestrate the process. Local officials from remote places have fewer opportunities to go to the regional centre for training, since the trips are more expensive for them and take more time. A good solution for this problem could be on-site workshops organized by Regional Management Centres.

Our model calculations show that in addition to the effect of socio-economic characteristics, the emergence of VK groups is also influenced by the municipality head's personalia. The effects are different for districts (okrugs) and settlements. Age turned out to be a significant factor at the settlement level: younger leaders were more willing to introduce social media into their work. It appears likely that because of the settlement administration's small staff, its head will keep the social media groups personally. The 'newcomer' effect of the head coming from elsewhere turned out to be significant at the district level. The new head's urge to get acquainted with the local population and demonstrate one's performance could be a motivation to create a page on VK. Another significant characteristic of the district (okrug) head was winning the municipal elections as a self-nominated candidate, which requires arranging streamlined communication with citizens.

Clustering based on significant socio-economic factors revealed the territories in need of closer attention in the matters of digital technology promotion. They constitute a quarter of all settlements in the Northwestern Federal District. The region that most notably lagging behind the rest in terms of the use of social media in the work of local administrations is the Pskov Region. Attention should also be paid to the Novgorod and Vologda Regions. The Arkhangelsk Region, the Republics of Karelia and Komi have local aggregations of vulnerable settlements. The analysis has thus identified territories in regions of the Northwestern Federal District that require informational, consulting, educational and infrastructural support from the Regional Management Centres, as well as measures to augment digital presence on social media.

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References

1. Ashmanov, I., Kaspersky, N. 2022, *Digital Hygiene*, Piter, St. Petersburg, Russia (in Russ.).

2. Zavattaro, S. M., Sementelli, A. J. 2014, A critical examination of social media adoption in government: Introducing omnipresence, *Government Information Quarterly*, vol. 31, № 2, p. 257—264, https://doi.org/10.1016/j.giq.2013.10.007

3. Mikhaylova, A. A., Hvaley, D. V. 2023, Geography of the mobile internet in the border and interior regions of Russia, *Baltic Region*, vol. 15, № 3, p. 140—166, https://doi.org/10.5922/2079-8555-2023-3-8

4. Zemtsov, S. P., Demidova, K. V., Kichaev, D. Yu. 2022, Internet diffusion and interregional digital divide in Russia: trends, factors, and the influence of the pandemic, *Baltic Region*, vol. 14, № 4, p. 57—78. https://doi.org/10.5922/2079-8555-2022-4-4

5. Stepanova, V. V., Ukhanova, A. V., Grigorishchin, A. V., Yakhyaev, D. B. 2019, Evaluating digital ecosystems in Russia's regions, *Economic and Social Changes: Facts, Trends, Forecast,* vol. 12, № 2, p. 73—90, https://doi.org/10.15838/esc.2019.2.62.4 (in Russ.).

6. Arkhipova, M. Yu., Sirotin, V. P., Sukhareva, N. A. 2018, Development of a composite indicator for measuring the value and dynamics of digital inequality in Russia, *Voprosy statistiki,* vol. 25, № 4, p. 75—87 (in Russ.).

7. Briglauer, W., Dürr, N. S., Falck, O., Hüschelrath, K. 2019, Does state aid for broa0d-band deployment in rural areas close the digital and economic divide? *Information Economics and Policy*, vol. 46, p. 68—85, https://doi.org/10.1016/j.infoecopol.2019.01.001

8. Muñoz-Cañavate, A., Hípola, P. 2011, Electronic administration in Spain: From its beginnings to the present, *Government Information Quarterly*, vol. 28, № 1, p. 74—90, https://doi.org/10.1016/j.giq.2010.05.008

9. Mikhaylova, A. A. 2022, Intermunicipal Differences in the Digital Pereptiveness of the Population, *Monitoring of Public Opinion: Economic and Social Changes Journal (Public Opinion Monitoring),* № 4, p. 222—246, https://doi.org/10.14515/monitoring.2022.4.2006 (in Russ.).

10. Quaglione, D., Matteucci, N., Furia, D., Marra, A., Pozzi, C. 2020, Are mobile and fixed broadband substitutes or complements? New empirical evidence from Italy and implications for the digital divide policies, *Socio-Economic Planning Sciences*, vol. 71, 100823, https://doi.org/10.1016/j.seps.2020.100823

11. Ivashinenko, N. N., Teodorovich, M. L., Varyzgina, A. A. 2020, Digital inequality: internet technologies in activation of consumer behavior, Logos et Praxis, vol. 19, № 3, p. 27—36, https://doi.org/10.15688/lp.jvolsu.2020.3.3 (in Russ.).

12. Sekushina, I. A. 2022, Digitalization of Small and Medium-Sized Cities in the European North of Russia: Trends and Prospects, *Economic and Social Changes: Facts, Trends, Forecast*, vol. 15, № 6, p. 124—138, https://doi.org/10.15838/esc.2022.6.84.7

13. Prokopiev, E. A., Kurilo, A. E., Gubina, O. V. 2019, The Formation of Digital Space at the Municipal Level: Overview of Settlements' Websites, *Economic and Social Changes: Facts, Trends, Forecast*, vol. 12, № 5, p. 76—90, https://doi.org/10.15838/esc.2019.5.65.5

14. Mergel, I. 2012, The social media innovation challenge in the public sector, *Information Polity*, vol. 17, № 3, 4, p. 281—292, https://doi.org/10.3233/IP-2012-000281

15. Cho, S., Mossberger, K., Swindell, D., Selby, J. D. 2021, Experimenting with Public Engagement Platforms in Local Government, *Urban Affairs Review*, vol. 57, № 3, p. 763—793, https://doi.org/10.1177/1078087419897821

16. Gellerstedt, M., Norström, L., Bernhard, I., Gråsjö, U., Snis, U. L. 2020, Do Municipal Facebook1 Performance and Citizen Satisfaction go Hand in Hand? *Electronic Journal of e-Government*, vol. 18, № 1, https://doi.org/10.34190/EJEG.18.1.003

17. Bonsón, E., Royo, S., Ratkai, M. 2017, Facebook Practices in Western European Municipalities: An Empirical Analysis of Activity and Citizens' Engagement, *Administration & Society*, vol. 49, № 3, p. 320—347, https://doi.org/10.1177/0095399714544945

18. Criado, J. I., Rojas-Martín, F., Gil-Garcia, J. R. 2017, Enacting social media success in local public administrations: An empirical analysis of organizational, institutional, and contextual factors, *International Journal of Public Sector Management*, vol. 30, № 1, p. 31—47, http://dx.doi.org/10.1108/IJPSM-03-2016-0053

19. Gao, X., Lee, J. 2017, E-government services and social media adoption: Experience of small local governments in Nebraska state, *Government Information Quarterly*, vol. 34, № 4, p. 627—634, https://doi.org/10.1016/j.giq.2017.09.005

20. Guillamón, M.-D., Ríos, A.-M., Gesuele, B., Metallo, C. 2016, Factors influencing social media use in local governments: The case of Italy and Spain, *Government Information Quarterly*, vol. 33, № 3, p. 460—471, https://doi.org/10.1016/j.giq.2016.06.005

21. Lev-On, A., Steinfeld, N. 2015, Local engagement online: Municipal Facebook pages as hubs of interaction, *Government Information Quarterly*, vol. 32, № 3, p. 299—307, https://doi.org/10.1016/j.giq.2015.05.007

22. Reddick, C. G., Jaramillo, P. A. 2014, New digital media use and preferences for government: a survey of Canadians, *Electronic Government, an International Journal*, vol. 11, № 1/2, p. 39—58, https://doi.org/10.1504/EG.2014.063313

23. Larsson, A. O. 2013, Bringing it all back home? Social media practices by Swedish municipalities, *European Journal of Communication*, vol. 28, № 6, p. 681—695, https://doi.org/10.1177/0267323113502277

24. Boev, E. I., Zotov, V. V., Vasilenko, L. A. 2023, Digitalization of public administration: expert reflection on problems and challenges, *Digital Sociology,* vol. 6, № 1, p. 4—12, https://doi.org/10.26425/2658-347X-2023-6-1-4-12 (in Russ.).

25. Vasilenko, L. A., Zotov, V. V., Zakharova, S. A. 2020, Social media potential for developing participatory governance, *RUDN Journal of Sociology,* vol. 20, № 4, p. 864—876, https://doi.org/10.22363/2313-2272-2020-20-4-864-876 (in Russ.).

26. Zimova, N. S., Fomin, Y. V., Smagina, A. A. 2020, Social networks as a new channel of interaction between government and society, *Research Result. Sociology and Management,* vol. 6, № 2, p. 159—171, https://doi.org/10.18413/2408-9338-2020-6-2-0-11 (in Russ.).

[1] Соцсеть *Facebook* принадлежит Meta— организации, деятельность которой признана экстремистской и запрещена на территории РФ.

27. Sytykh, E. L., Kravtsova, A. V. 2020, Social networks as a political resource (for example, the Instagram1 account of the governor of the Chelyabinsk region A. L. Teksler), *Scientific Annual Publication of the Analysis and Forecast Centre*, № 1, p. 195—200. EDN: YELSUI (in Russ.).

28. Kondratyeva, O. N., Chernova, Zh. V. 2019, Self-Presentation of the Politician in Social Networks (On a Material of Official Page in the Social Network "VKontakte" of the Governor of the Kemerovo Area of Sergey Tsivilev), *Vestnik NSU. Series: History and Philology*, vol. 18, № 6, p. 129—138, https://doi.org/10.25205/1818-7919-2019-18-6-129-138 (in Russ.).

29. Mityeva, Yu. A., Chernyshev, Yu. G. 2013, The Use of Social Networks and Blogs in Shaping the Image of the Governors of South-Western Siberia*, Izvestiya of Altai State University*, № 4-1, p. 281—286. EDN: RAGJGB (in Russ.).

30. Filatova, O. G. 2020, Heads of Russian Regions in Social Media: Audit of Public Communications, PR i reklama v izmenyayushchemsya mire: regional'nyi aspekt, № 23, p. 6—16. EDN: FTADBA (in Russ.).

31. Prokopyev, E. A. 2023, The Average Wage in the North-West Federal District: An Assessment of Territorial Disparities on a Settlement Level, *Russian Journal of Regional Studies*, vol. 31, № 2, p. 335—356, https://doi.org/10.15507/2413-1407.123.031.202302.335-356 (in Russ.).

32. Zamyatina, N. Yu., Yashunsky, A. D. 2018, Virtual geography of virtual population, *Monitoring of Public Opinion: Economic and Social Changes Journal (Public Opinion Monitoring),* № 1, p. 117—137, https://doi.org/10.14515/monitoring.2018.1.07 (in Russ.).

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[1] Соцсеть *Instagram* принадлежит Meta — организации, деятельность которой признана экстремистской и запрещена на территории РФ.

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2) an English-language summary (150—250 words) compiled in accordance with international standards. The summary should effectively cover:

— an introduction to the topic;

— the purpose of research;

— a description of the research and practical significance of the work;

— a description of the research methodology;

— key results and conclusions;

— the significance of research (the contribution it made to the corresponding field of knowledge);

— practical significance of research results.

The summary should not reproduce the text of the article (i.e. copy sentences from the article verbatim) or its title. The summary should not contain digits, tables, footnote markers, etc.;

3) English key words (4—8 words);

4) bibliography (⩽ 30 sources) formatted in compliance with the Harvard System of Referencing;

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All materials should be submitted as electronic documents formatted to A4 paper size (210 × 297 mm).

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