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Миссия журнала «R-Economy» – обеспечить публикацию исследований в области региональной экономики. Мы считаем сотрудничество с экономистами из стран БРИКС нашим главным приоритетом. «R» в названии журнала ссылается на три его базовых направления – Region (региональное развитие), Regulation (сравнительное изучение региональной политики) и Reconfiguration (пространственные социально-экономические и политические преобразования).

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The U-shaped relationship between low carbon goods trade and emission reductions: insights from Russian regions

ABSTRACT
Relevance. The global imperative for adopting a low-carbon economy resonates worldwide, yet comprehensive assessments specific to the Russian economy remain scant. This is especially important considering the significant differences in the level of transition to sustainable development among Russian regions.
Research Objective. This study aims to introduce a robust methodology for evaluating and analyzing the international trade of low-carbon goods (LCGs) across various Russian regions and assessing its effects on fuel combustion emissions.
Data and Methods. Data on LCGs trade were obtained from the Federal Customs Service of Russia. In conjunction, datasets from Rosstat and the Central Bank of Russia were incorporated for comprehensive econometric modeling. The analytical framework employed Tobit and quantile regressions.
Results. The study uncovers significant disparities among Russian regions regarding the intensity of low-carbon goods exports and imports. This variation highlights the diverse competencies in LCGs production, as well as differing ecological agendas and consumption patterns across regions. Additionally, the research demonstrates that, although the widespread adoption of advanced production technologies is positively correlated with increased fuel combustion emissions, a U-shaped relationship exists where higher LCGs exports are associated with reductions in fuel combustion emissions across Russian regions to a certain degree.
Conclusions. This research highlights important implications for both federal and regional industrial and environmental policies. It advocates for the development of targeted incentives that encourage the adoption of low-carbon goods (LCGs) and advanced technologies. By doing so, policymakers can effectively promote sustainable development tailored to the unique needs and conditions of various regions, thereby fostering ecological resilience and economic growth across diverse regional landscapes.

KEYWORDS
low carbon goods (LCGs), export of Russian regions, import of Russian regions, fuel combustion emissions, advanced manufacturing technologies, Russian regions, regional disparities, regional development, International trade

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U-образная взаимосвязь между торговлей товарами с низко углеродными технологиями и сокращением выбросов: выводы по регионам России

АННОТАЦИЯ
Актуальность. Глобальная необходимость перехода к низкоуглеродной экономике охватывает весь мир, однако комплексные оценки, специфичные для российской экономики, остаются редкими. Это особенно важно с учетом значительных различий в уровне перехода к устойчивому развитию среди российских регионов.
Цель исследования. Данное исследование направлено на разработку методики для оценки и анализа международной торговли товарами с низкоуглеродными технологиями (ТНУТ) в различных регионах России и оценку ее влияния на выбросы при сжигании топлива.
Данные и методы. Данные о торговле ТНУТ были получены на основе данных Федеральной таможенной службы России. В дополнение были использованы наборы данных Росстата и Центрального банка России для проведения комплексного эконометрического моделирования. В аналитической модели использован регрессионый анализ с применением Тобит и квантильных оценок.
Результаты. Исследование выявило значительные различия между регионами России по интенсивности экспорта и импорта товаров с низко углеродными технологиями. Это различие подчеркивает разнообразные компетенции в производстве ТНУТ, а также различие в экологических повестках и потребительских предпочтениях регионов. Кроме того, результаты показывают, что, хотя широкое внедрение низко углеродных технологий положительно коррелирует с увеличением выбросов при сжигании топлива, существует U-образная взаимосвязь, при которой увеличение экспорта ТНУТ связано с сокращением выбросов топлива в российских регионах только до определенной степени.
Выводы. Исследование обсуждает следствия для федеральной и региональной промышленной и экологической политики. Обсуждается необходимость разработки целевых стимулов, которые способствуют внедрению товаров с низко углеродными технологиями. Политика может эффективно содействовать устойчивому развитию, адаптированному к уникальным потребностям и условиям различных регионов, что будет способствовать экологической устойчивости и экономическому росту в разных региональных ландшафтах.

КЛЮЧЕВЫЕ СЛОВА
товары с низко углеродными технологиями, экспорт регионов России, импорт регионов России, выбросы при сжигании топлива, передовые производственные технологии, российские регионы, региональные диспропорции, региональное развитие, международная торговля

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采用低碳技术的货物贸易与减排之间的 U 型关系：俄罗斯地区的研究结果

摘要
现实性：全球都需要向低碳经济转型，但专门针对俄罗斯经济的全面评估仍然很少见。鉴于俄罗斯各地区在可持续发展转型水平方面存在巨大差异，这一点尤为重要。
研究目**标：**本研究旨在开发一种方法，用于评估和分析在国际贸易中，俄罗斯不同地区的低碳技术产品特点，并评估其对燃料燃烧排放的影响。
数据与方法：低碳技术产品贸易数据来自俄罗斯联邦海关总署。此外，俄罗斯国家统计局和俄罗斯中央银行的数据也被用于进行复杂的计量经济学建模。分析模型采用了带有Tobit和量化估计的回归分析。
研究**结果：**研究显示，俄罗斯各地区在低碳技术产品的进出口强度方面存在显著差异。这种差异显示出各地区在低碳技术生产能力方面、环境议程和消费者偏好方面的不同。此外，研究结果表明，虽然低碳技术的广泛应用与燃料燃烧排放的增加呈正相关，但在俄罗斯各地区，低碳技术产品出口的增加与燃料排放的减少在一定程度上呈“U”型关系。
结论：该研究讨论了联邦和地区工业及环境政策的影响。它讨论了制定有针对性的激励措施来促进低碳产品的必要性。政策可以有效地促进符合不同地区独特需求和条件的可持续发展，从而在不同地区促进环境可持续性和经济增长。

关键词
低碳产品、俄罗斯的地区出口、俄罗斯的地区进口、燃料燃烧产生的排放、先进制造技术、俄罗斯地区、地区差距、地区发展、国际贸易

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Introduction

Over the past decade, there has been a significant increase in interest in analyzing the production and use of goods within the low-carbon economy. This surge is linked to the growing frequency and severity of environmental disasters and the challenges associated with meeting the United Nations Sustainable Development Goals. Despite the increasing interest and urgency, the development of green technologies is constrained by uncertainties related to climate change, technological advancements, and environmental policies (Haas et al., 2023; Knutti et al., 2010; Stern, 2016; Way et al., 2022; Portansky, 2014).

Interestingly, over the last twenty years, the share of green and renewable products in total trade volume has not increased (Mealy, Teytelboym, 2022). One reason is that many green and renewable energy products, while offering significant advantages over traditional technologies, also come with certain drawbacks.

Low-carbon technologies offer significant advantages, primarily due to their lower emissions intensity compared to carbon-intensive alternatives. For instance, solar and wind power plants emit minimal CO2 during operation, contrasting sharply with coal-fired plants. Despite considerations like production and disposal, renewable energy equipment maintains a lower CO2 footprint per unit of energy produced. These technologies are versatile across sectors (Berger et al., 2020; Gerres et al., 2019), encompassing applications from electric vehicles in transportation to solar panels and wind turbines in energy, and low-emission processes in manufacturing. This diversity necessitates tailored technological advancements suited to specific industrial and regional contexts. Another advantage is their knowledge spillover effect, fostering broader dissemination of clean technology knowledge (Dechezleprêtre et al., 2017). Yet, challenges persist. Implementing these technologies demands technical and economic sophistication, such as developing efficient energy storage and transmission systems (Mealy, Teytelboym, 2022). Initial high costs also hinder adoption, despite potential long-term economic benefits (Jaffe, Stavins, 1995; Ivanova et al., 2022).

Resistance from vested interests in carbon-intensive sectors complicates adoption (Fedyunina, Simachev, 2024). Moreover, infrastructure gaps and resource availability, like sunlight and wind, influence technology deployment. Successful adoption hinges on supportive government

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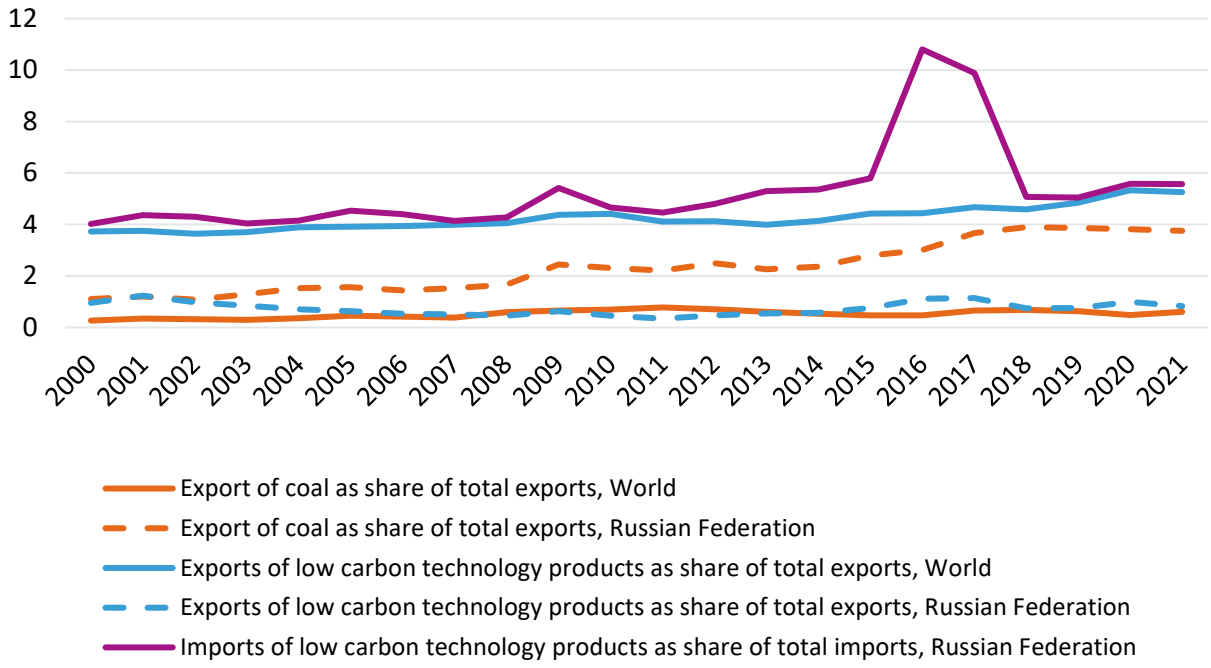

Figure 1. *Share of Coal and LCGs in Global Exports, 2000–2021*

Source: Compiled by the authors based on the International Monetary Fund. 2022.Climate Change Indicators Dashboard. Retrieved from https://climatedata.imf.org/pages/access-data (05.05.2024).

policies (Kazantseva, 2020; Popadko, Naidenova, 2020), which may include tax breaks and tariff incentives to encourage investment in renewable energy.

In conclusion, while low-carbon technologies offer substantial benefits, their widespread adoption requires overcoming technical, economic, and policy barriers in a complex socio-economic landscape (Acemoglu et al., 2016; Aghion et al., 2016). In summary, while low-carbon technologies offer numerous advantages and are essential for a sustainable future, their adoption is fraught with complexities and challenges that require coordinated efforts in policy, infrastructure, and technological innovation. The ambiguity and high level of debate surrounding the adoption of low-carbon technologies is particularly evident in the assessment of the share of low-carbon goods (LCGs) in global trade[1]. The share of LCGs in global exports increased from 3.7% in 2000 to 5.3% in 2021, with an average annual growth rate of less than 2% over this period. During the same period, the share of international coal trade also grew, effectively doubling to 0.6% of global trade by 2021 (Figure 1). Indeed, despite the currently emerging paradigm of a carbon-free energy development concept, the coal industry has all the necessary prospects for development (Nikitenko et al., 2023).

The situation regarding the spread of LCGs in the global economy is similarly complex for Russia. Over the period from 2000 to 2021, Russia has not managed to significantly increase its LCG exports, with their share in Russian exports remaining just below 1%. However, the country has been able to increase its LCG imports, with their share in gross imports rising from 4% in 2000 to 5.6% by 2021, even surpassing 10% in 2016–2017 (see Figure 1). This trend reflects recent expert analyses, which indicate that the low-carbon economy agenda has only recently begun to develop in Russia. While integrating into global technological chains in this field shows great promise, the scale of implementing low-carbon technologies within the country, although highly relevant, remains modest (Bashmakov, 2019; Bashmakov, 2020; Popova, Kolmar, 2023).

Russian regions vary significantly in the structure and efficiency of their regional energy systems, as well as in their methods for reducing pollutants (Khrustalev, Ratner, 2015). Reducing the

[1] In this study, we define low carbon goods as products that produce less pollution than their traditional energy counterparts and will play a vital role in the transition to a low carbon economy similar to (Pienknagura, 2024).

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negative environmental impact of the economy is a challenge that involves not only investment and technology but also methodological approaches. When developing economic projects for different territories, decision-makers must consider the diverse social, environmental, and economic effects (Ratner, 2016). Additionally, there is still considerable uncertainty regarding the data available for assessing the production and use of LCGs in Russian regions.

In light of the above, we believe it is crucial to continue research focused on the heterogeneity of sustainable development across Russian regions. To achieve this, we propose to examine these issues from a fresh perspective. Our goal is to expand the understanding of indicators related to the sustainable development of Russian regions and assess how they are linked to the reduction of fuel combustion emissions. Our main hypothesis is that the relationship between sustainable development and emission reduction may be nonlinear in Russian regions due to significant differences in accumulated competencies in sustainable development and a high level of regional disparities.

We introduce a novel methodology and, to the best of our knowledge, evaluate the trade of Russian regions in low-carbon goods (LCGs) for the first time. This approach can serve as a new indicator for measuring sustainable development in these regions. The findings obtained enhance and broaden the existing understanding of the disparities in production competencies and demand for sustainable development goods among Russian regions. Furthermore, we employ Tobit and quantile regression techniques to assess the role of LCGs trade in reducing CO2 emissions and identify a non-linear relationship between LCGs trade and emissions. This analysis allows us to derive implications for industrial policy at both the regional and federal levels.

This study expands on existing research in two main areas. First, we propose a methodology and present the results of assessing international trade in LCGs by Russian regions from 2016 to 2021. These assessments allow us to identify the goods that hold the largest share in Russia's gross exports and imports of LCGs. We discuss the intensity of LCG exports and imports across Russian regions and highlight significant differences between various federal districts and regions. Second, we assess the role of LCG exports and imports in reducing carbon dioxide emissions from fuel combustion, demonstrating that regional competencies in LCG production positively are positively related to the reduction of these emissions.

The paper is structured as follows. Section 2 presents our methodology for assessing international trade in LCGs for Russian regions, discusses the results obtained, and introduces the data and methods used for econometric modeling. Section 3 presents the results of the econometric assessment of the role of international trade in LCGs in Russian regions in reducing carbon dioxide emissions from fuel combustion. Finally, Section 4 discusses the findings, limitations, and directions for future research.

Theoretical basis

Our analysis draws on several key theoretical frameworks in environmental economics and regional development. Central to our approach is the Environmental Kuznets Curve (EKC) hypothesis, which posits an inverted U-shaped relationship between economic growth and environmental degradation (Grossman, Krueger, 1995). According to this theory, as regions undergo economic expansion, environmental conditions initially deteriorate due to increased industrial activity and energy consumption but improve over time as economies mature and adopt cleaner technologies. The EKC has attracted significant attention from researchers and has been empirically validated in numerous studies across different regions and countries (Bibi & Jamil, 2021; Dogan, Inglesi-Lotz, 2020; Mahmood et al., 2023). This hypothesis has also been confirmed in studies of the Russian economy and its regions (Mariev et al., 2020; Ketenci, 2018; Shkiperova, 2013), providing robust evidence of the U-shaped relationship between economic growth and emissions in Russia.

Additionally, we consider the role of foreign direct investment (FDI), drawing on the pollution haven hypothesis (Cole, 2004; Gill et al., 2018) and pollution halo hypothesis (Abid, Sekrafi, 2021; Zarsky, 1999), which explore how FDI can either increase emissions in regions with lax environmental regulations or contribute to emissions reductions through technology transfer and innovation. To capture the technological dimension, we include the number of advanced manufacturing technologies utilized, aligning with the Porter Hypothesis (Porter, van der Linde, 1995), which

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suggests that environmental regulations can drive innovation and resource efficiency. Furthermore, urbanization is factored into our model, as densely populated regions often exhibit higher energy consumption and emissions, though they may also benefit from cleaner infrastructure and governance systems as they develop (York, Rosa, & Dietz, 2003). Finally, by incorporating trade in low carbon goods (LCGs), we align with the trade and environment nexus, which examines how trade can influence emissions through both the scale and technique effects (Copeland, Taylor, 2004). These theoretical foundations provide a comprehensive basis for understanding the environmental impacts of LCGs trade across Russian regions.

Methods and data

Method of estimation of trade in LCGs in Russian regions

Defining which products fall under the category of low-carbon goods (LCGs) is a complex task (Pigato et al., 2020). This complexity was notably highlighted by the failure of the WTO Environmental Goods Agreement negotiations in late 2016, where negotiators could not agree on competing lists of low-carbon goods (De Melo and Solleder, 2019). Despite the lack of consensus on an official list of LCGs, recent work by Pigato et al. (2020) proposes utilizing three distinct and widely recognized lists compiled by various stakeholders: the World Bank, the Asia-Pacific Economic Cooperation (APEC) multilateral forum, and academic researchers (Glachant et al., 2013).

In this study, we adopt the approach of Pigato et al. (2020) to identify low-carbon goods. Using the commodity classification of the EAEU HS, we are able to identify 105 LCGs. These LCGs encompass a range of non-raw material, non-energy goods at various stages of production, predominantly at the advanced stages. Specifically, 96 out of the 105 goods fall into the category of high-end products, 8 are classified as intermediate products, and 1 is categorized as a basic product.

By focusing on these classifications, our research aims to provide a clear framework for identifying and analyzing low-carbon goods within the broader context of global trade and economic policy.

Trade in LCGs in Russian regions

For this study, using data from the Russian Federal Customs Service (FCS) for each federal subject of Russia over the period from 2016 to 2021 (based on the availability of FCS data), we assessed the volumes of LCG exports and imports for each region. Additionally, we calculated relative indicators that reflect the proportion of LCG trade to overall trade and the Gross Regional Product (GRP) of the regions.

According to our estimation methodology, the commodity structure of Russian LCGs exports is diversified, with the top three positions holding relatively small shares. These are Heat exchange units, whether or not electrically heated (2.1% of Russia's gross exports from 2016-2021), Measuring/checking instruments, apparatus, and machines (1.6%), and Boards, panels, consoles, desks, cabinets, and other bases for electric control or distribution of electricity (1.5%). All these categories are crucial for low carbon economy.

Heat exchange units, whether or not electrically heated, are essential for energy-efficient heating and cooling systems, such as heat pumps and waste heat recovery systems. By reducing energy consumption and emissions, these exports significantly contribute to Russia's global efforts in promoting sustainable energy practices and reflect the presence of domestically competitive products in this category on the global market. Measuring/checking instruments, apparatus, and machines play a critical role in monitoring and optimizing the performance of various low carbon technologies. They are indispensable for renewable energy installations, smart grids, and energy-efficient processes, providing accurate data crucial for enhancing operational efficiency and mitigating environmental impacts. Lastly, Boards, panels, consoles, desks, cabinets, and other bases for electric control or distribution of electricity are vital for managing and optimizing electricity distribution within renewable energy systems like solar and wind power. They also support smart grids and energy storage systems, thereby improving the efficiency and reliability of low carbon energy solutions.

The list of the top 10 LCGs by share in Russia's gross exports according to our methodology is provided in Appendix 1. Overall, this table highlights Russia's export strengths in essential components and technologies that play a foundational role in global low carbon initiatives.

Top 3 positions in Russia's LCGs import structure from 2016 to 2021 include Machinery for liquefying air or other gases (15.3% share of

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Table 1

Contribution of LCGs as a Percentage of Gross Exports, Imports, and GRP in Russian regions, Average for 2016–2021

Federal District	LCG Exports (% of Gross Exports)	LCG Exports (% of GRP)	LCG Imports (% of Gross Imports)	LCG Imports (% of GRP)
Ural Federal District	3.238	0.194	0.137	0.023
Southern Federal District	2.162	0.059	0.379	0.041
Siberian Federal District	2.103	0.254	0.050	0.007
Northwestern Federal District	2.074	0.314	0.095	0.005
Volga Federal District	0.914	0.094	0.586	0.030
Central Federal District	0.615	0.013	1.105	0.054
North Caucasian Federal District	0.510	0.126	0.552	0.022
Far Eastern Federal District	0.153	0.046	1.555	0.147
Russian regions (average)	1.467	0.153	0.511	0.039
Russian regions (minimum)	0.000	0.000	0.000	0.000
Russian regions (maximum)	20.204	3.385	13.357	1.912
Russian regions (median)	0.553	0.063	0.052	0.004

Source: Authors' calculations

total imports), Electrical control and distribution apparatus (9.0% share), and other machines and mechanical appliances (7.9% share). These categories play a crucial role in advancing Russia's transition to low carbon technologies. Machinery for liquefying air or other gases supports critical air separation processes essential for renewable energy production and carbon capture technologies. Its significant import share underscores Russia's dependence on this advanced equipment to enhance sustainable energy capabilities. Electrical control and distribution apparatus are essential for efficiently managing electricity in renewable energy systems, such as solar and wind technologies. Their substantial import share highlights their role in improving reliability and efficiency within Russia's evolving low carbon infrastructure. Lastly, other machines and mechanical appliances are vital for manufacturing components used in renewable energy technologies, including electric motors for wind turbines and batteries for electric vehicles. This category's import share emphasizes its pivotal contribution to Russia's efforts in developing and manufacturing low carbon solutions. For a detailed list of the top 10 largest positions in Russia's LCGs import, please refer to Appendix 2.

The obtained estimates of LCGs exports and imports in Russian regions align with previous observations (Khrustalev, Ratner, 2015) regarding significant differences between Russian territories. Specifically, we find that the share of LCGs exports in gross exports is highest in industrially developed regions. At the federal district level, the Ural Federal District leads in this indicator, with LCG exports constituting 3.2% of gross exports. The Siberian Federal District and the Southern Federal District follow closely, with high intensities of 2.1–2.2%. The development of their own production capacities, as confirmed by export intensity, has led to a relatively low contribution of LCG imports to gross imports in these federal districts (Table 1).

Although the obtained estimates do not directly measure the volumes of production and consumption of low carbon goods (LCGs) across Russian regions, they provide valuable insights. On one hand, export data can be used to assess the presence of competitive production capacities for LCGs, which, through external effects, can promote greater consumption of LCGs within the same region. On the other hand, import data can be utilized to proxy the demand for LCGs. Despite some limitations of this approach, such as potentially underestimating production and consumption volumes, foreign trade data often serve as the only convenient source for assessing the production and use of advanced manufacturing technologies at the national and regional levels (Simachev et al., 2021). For further analysis, we will use these

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export and import estimates of LCGs to explain the volumes of carbon dioxide emissions from fuel combustion.

Data and methods of econometric estimation

To evaluate the environmental impact of low carbon goods (LCGs) in Russian regions, we employ the standard metric of atmospheric pollutant emissions from fuel combustion (for electricity and heat production) for the reporting year (Mariev et al., 2020). Using per capita measurements for all indicators is advisable to mitigate potential endogeneity issues. Larger regions are more likely to have industrial sectors that export and import LCGs, while also generating higher emissions from fuel combustion.

Our model incorporates control variables based on findings from previous studies that explain per capita emissions. Specifically, we include inflows of foreign direct investment, the number of advanced manufacturing technologies utilized, electricity consumption, and the urban population share. Additionally, we incorporate Gross Regional Product (GRP) per capita and its square, aligning with the Kuznets curve hypothesis, which posits a relationship between economic growth and environmental degradation. According to this hypothesis, environmental conditions initially deteriorate with economic growth but subsequently improve as the economy matures. This improvement is attributed to the increased capacity of a growing economy to invest in clean technologies and environmental protection. Conversely, in the early stages of economic development, countries may prioritize economic growth over environmental protection, leading to environmental degradation. This hypothesis has been validated for Russian regions in several studies (Mariev et al., 2020; Shkiperova, 2013).

Based on the Kuznets curve hypothesis and recent empirical studies explaining emissions associated with energy production, we employ the following variables, as presented in Table 2.

Table 2

Variables Used: Definitions, Sources and References

Variable name	Definition	Data source	References
Dependent variable			
lncarbempop	Emissions of pollutants into the atmosphere from fuel combustion (for electricity and heat generation) (carbon oxide) thousand tons per thousand population, logarithm	EMISS	Mariev et al., 2020;
Explanatory and control variables			
lnlctimpop	Import of LCGs per capita, USD, logarithm	Authors' calculations	
lnlctexppop	Export of LCGs per capita, USD, logarithm	Authors' calculations	
lngrppc	GRP per capita, RUB, logarithm	Rosstat	Ali et al., 2019; Muhammad et al., 2020; Xu, Lin, 2016; Mariev et al., 2020;
lngrppc2	Square of GRP per capita, RUB, logarithm	Authors' calculations	Grossman, Krueger, 1991; Xie, Liu, 2019; Mariev et al., 2020; Schkiperova et al., 2013;
ifdipop	Inflow of foreign direct investment per thousand population, million USD, logarithm	Central Bank of Russia	Muhammad et al., 2020; Mariev et al., 2020;
lnamtpop	Number of advanced manufacturing technologies used per thousand population, logarithm	Rosstat	Xie, Liu, 2019; Mariev et al., 2020;
lnenergyconspop	Electricity consumption per thousand population, million kWh	Rosstat	Ali et al., 2019; Muhammad et al., 2020; Mariev et al., 2020;
cityshare	Urban population share, %	Rosstat	Ali et al., 2019; Muhammad et al., 2020; Xie, Liu, 2019; Xu, Lin, 2016; Mariev et al., 2020;

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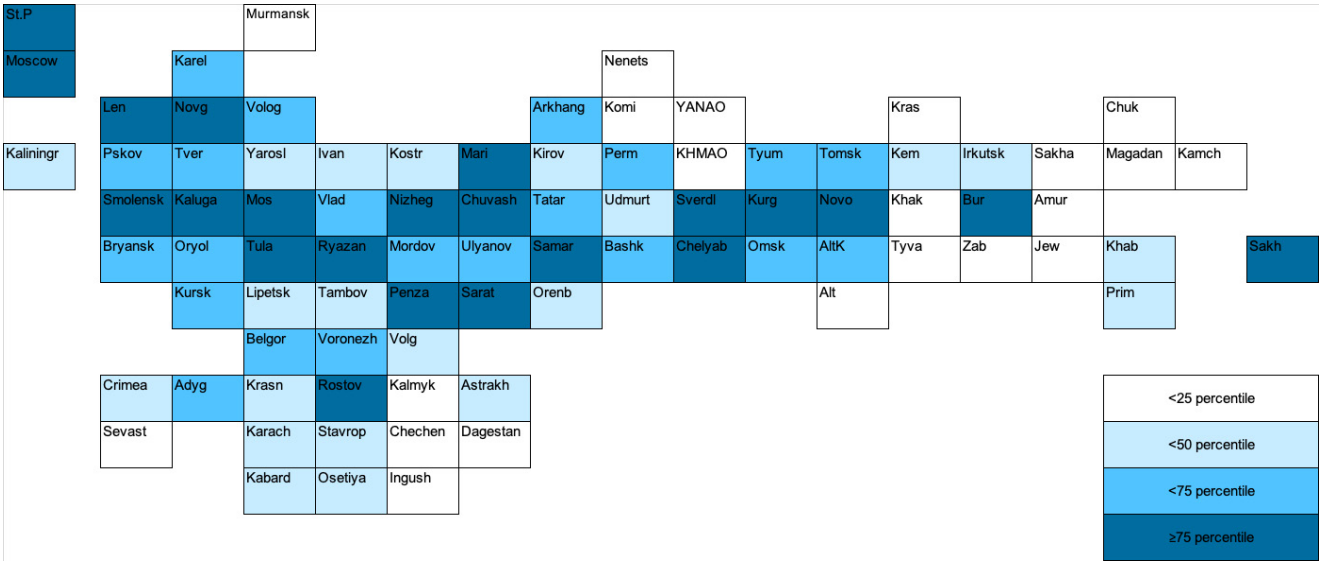

Figure 2. *Share of LCG exports in GRP across Russian regions (%), average for 2016–2021*

Source: Compiled by the authors based on own calculations

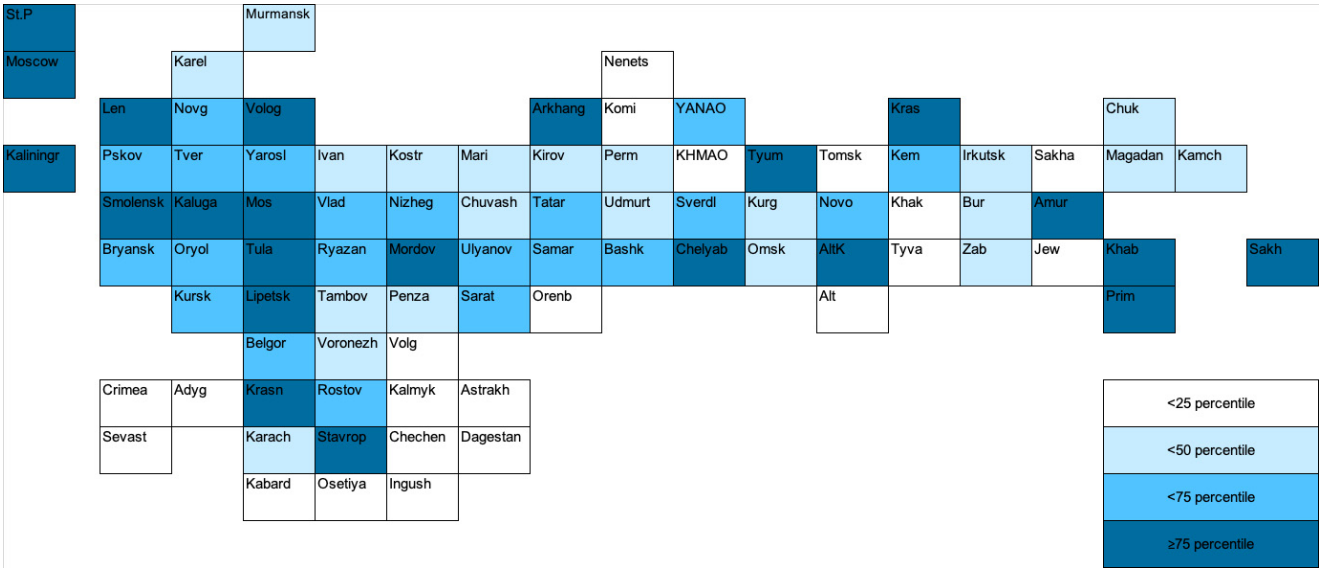

Figure 3. *Share of LCG imports in GRP across Russian regions (%), average for 2016–2021*

Source: Compiled by the authors based on own calculations

The novelty of our study lies in our departure from previous research by incorporating per capita volumes of LCG exports and imports as a key factor explaining emissions from fuel combustion. Additionally, we introduce the number of advanced manufacturing technologies used in the region as an additional variable reflecting the technological level of production. Previous studies utilized absolute and relative volumes of exports and imports (e.g., Muhammad et al., 2020; Mariev et al., 2020) as control variables, while others included various variables capturing technological levels (e.g., Xie, Liu, 2019; Mariev et al., 2020). However, none have specifically focused on factors related to advanced and low-carbon technologies. Given the significant correlation between absolute volumes of exports and imports with LCG trade, we opted to exclude them to avoid multicollinearity issues.

Figures 2 and 3 illustrate the distribution of the share of LCG exports and imports in the GRP of Russian regions, averaged over the period 2016–2021. As the figures show, the share of exports is generally higher in industrially developed and diversified regions. The distribution of imports follows a similar pattern but is also higher in border

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Table 3

Descriptive Statistics of Variables

Variable	Number of observations	Mean	Std. dev.	Min	Max
lncarbempop	169	1.842	1.284	–2.256	5.150
lnlctimpop	168	9.677	1.786	0.559	12.992
lnlctexppop	162	7.936	2.278	–1.432	12.365
ifdipop	163	0.949	2.846	0.000	20.108
lnamtpop	169	0.307	0.862	–2.874	2.253
lnenergyconspop	169	1.885	0.702	0.465	4.172
cityshare	169	70.750	12.983	29.3	100
lngrppc	169	13.095	0.628	11.865	15.558

Source: Authors' calculations

regions, which is likely due to the specific features of goods entry and declaration. Imports provide less information about the region where imported goods are consumed, as goods can be further distributed to other regions after their entry.

Descriptive statistics of the variables used in the model is presented below in table 3. Although data on the export and import of LCGs spans the period from 2016 to 2021, our study is limited by the availability of fuel combustion emissions data, which is only accessible for the years 2019-2020. This restriction narrows our sample to just these two years, thereby influencing the methodologies we can employ, as we will discuss further. However, we benefit from the fact that the remaining variables are available over a longer period, and we utilize all explanatory and control variables with their first lag to further mitigate the endogeneity issue caused by simultaneity in the model.

In this study, we employ the Tobit method to analyze data with a non-uniform distribution of the dependent variable ranging from –3 to 6. This method is suitable for modeling situations where the dependent variable is censored (bounded above and below). Such constraints are common in socio-economic and psychological phenomena and addressing them is crucial for reliable analysis. The Tobit method correctly handles these bounds, accounting for measurement limitations or assumed maximum (minimum) levels. It also adheres to assumptions of residual normality and linearity between dependent and independent variables, ensuring model adequacy and minimizing distortions for enhanced statistical efficiency.

Alternatively, quantile regression could be used for estimation. This method is advantageous for several reasons. Firstly, it allows analysis at different quantile levels of the dependent variable, which is useful for non-uniformly distributed data as it captures changes in relationships across different levels (as shown in Figure 4). Secondly, quantile regression does not require residual normality or linearity assumptions, offering greater flexibility and robustness for non-standard distributions. Additionally, it accommodates outliers and extreme values, which is important in studies with significant data variability.

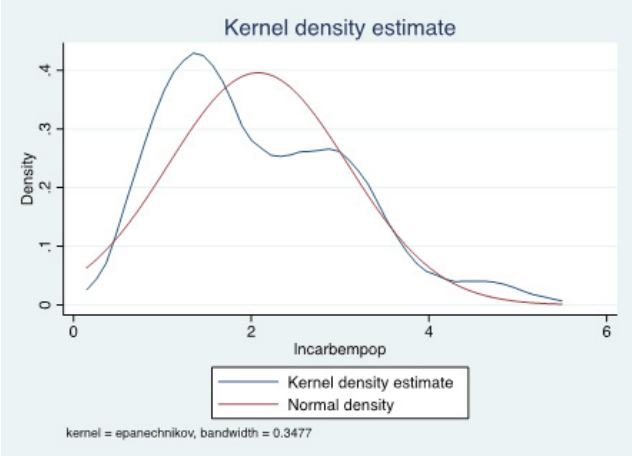

Figure 4. *Distribution of lncarbempop variable and normal distribution*

Source: Compiled by the authors based on own calculations

Results

Empirical results from Tobit regression are presented in Table 4, and results from quantile regression are detailed in Table 5. Key findings are summarized below.

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Table 4

Trade in LCGs as a Determinant of Pollutant Emissions from Fuel Combustion: Tobit Regression Results

Variables	(1)	(2)
lctexppop (t-1)	–0.219***	
	(0.0412)	
lnlctimpop (t-1)		–0.0961
		(0.0594)
lngrppc (t-1)	2.709	1.232
	(4.3590)	(3.4770)
lngrppc2 (t-1)	–0.0751	–0.0216
	(0.1620)	(0.1270)
ifdipop (t-1)	–0.0351	–0.0303
	(0.0497)	(0.0441)
lnamtpop (t-1)	0.557***	0.342***
	(0.1180)	(0.1090)
lnenergyconspop (t-1)	0.425**	0.690***
	(0.1680)	(0.1630)
cityshare (t-1)	–0.00742	–0.00881
	(0.0076)	(0.0080)
Constant	–19.37	–10.39
	(29.0800)	(23.4100)
Observations	154	165
Pseudo R-sq	0.2014	0.1844
Prob>Chi2	0.000	0.000

Notation. Hereinafter *** indicates 1% significance level, ** indicates 5% significance level, * indicates 10% significance level. Standard errors are indicated in parentheses. Dummy variable for 2020 is included, but not reported.

Source: Authors' calculations

Firstly, irrespective of the estimation method used, our results exhibit substantial consistency. We find that per capita exports of LCGs in Russian regions are associated with reductions in fuel combustion emissions. This suggests that the presence of local producers of low carbon goods facilitates their adoption within the region, contributing to the broader agenda of sustainable development. Consequently, we observe that higher levels of LCGs exports correlate with decreased emissions from fuel combustion.

Regarding imports of LCGs, Tobit regression results indicate statistical insignificance, while significance is observed only at the 90th quantile in the quantile regression (column 10). This may indicate that domestic solutions dominate in most Russian regions, with imports playing a less prominent role.

Variables such as *lngrppc* (Gross Regional Product per capita) and *lngrppc2* (Gross Regional Product per capita squared) are statistically insignificant, thus failing to confirm the Environmental Kuznets Curve hypothesis at this stage. Interestingly, our exploration without key explanatory variables related to LCGs trade and the intensity of advanced production technologies initially suggested a confirmation of the Kuznets Curve hypothesis. This implies that regional adoption of advanced technologies influences the curve, warranting further investigation in future studies.

Among other control variables, we find that *lnamtpop* (per capita use of advanced production technologies) is positively associated with fuel combustion emissions. This aligns with findings from both Tobit and quantile regressions across most quantiles (columns 1–4 and 6–8). This result suggests that the complexity and energy-intensive nature of advanced production processes contribute to higher electricity consumption in regions. Moreover, it is important to recognize that the development of advanced technologies in the energy-intensive sectors themselves, including coal mining and coal processing, is promising for Russian regions (Korolev et al., 2023).

Additionally, the influx of Foreign Direct Investment (FDI) exhibits a weakly negative association with emissions – statistically insignificant in Tobit regression and significant only in columns 1, 6, and 10 of the quantile regression. This finding may imply that FDI enterprises adhere to higher international environmental standards or preferentially invest in eco-friendly facilities with lower fuel combustion emissions.

Overall, the estimated regressions demonstrate satisfactory explanatory power. The Tobit model explains 18.4% to 20.1% of the variance in the dependent variable across two different specifications, while the quantile model ranges from 22.4% to 38% depending on the quantile considered.

Figure 3 displays the elasticity (coefficient) of the relationship between per capita exports and imports of LCGs and the reduction in fuel combustion emissions in Russian regions. As shown, the elasticity is negative. The elasticity for LCGs exports is negative and exhibits a U-shaped pattern, peaking approximately between the 50th and 80th quantiles. The elasticity for LCGs imports is also negative and declines monotonically, becoming statistically significant only after the 90th quantile.

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Table 5

Trade in LCGs as a Determinant of Pollutant Emissions from Fuel Combustion: Quantile Regression Results

Variables	Quantile					Quantile				
	Q10	Q25	Q50	Q75	Q90	Q10	Q25	Q50	Q75	Q90
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
lctexppop (t-1)	−0.128**	−0.189***	−0.217***	−0.239***	−0.182***					
	(0.0499)	(0.0586)	(0.0613)	(0.0670)	(0.0536)					
lnlctimpop (t-1)						0.0207	−0.0819	−0.0369	−0.122	−0.185**
						(0.0771)	(0.0694)	(0.0916)	(0.0931)	(0.0777)
lngrppc (t-1)	−1.491	2.377	1.667	−1.723	−17.16***	−2.446	−1.169	1.236	−4.759	−5.497
	(5.2840)	(6.2060)	(6.4880)	(7.0950)	(5.6770)	(4.5120)	(4.0590)	(5.3590)	(5.4490)	(4.5430)
lngrppc2 (t-1)	0.0611	−0.0701	−0.0463	0.0882	0.661***	0.106	0.0654	−0.0291	0.203	0.246
	(0.1960)	(0.2300)	(0.2400)	(0.2630)	(0.2100)	(0.1650)	(0.1480)	(0.1950)	(0.1990)	(0.1660)
ifdipop (t-1)	−0.174***	0.0249	−0.0386	−0.0727	−0.0461	−0.289***	−0.0158	0.0622	−0.0806	−0.141**
	(0.0602)	(0.0707)	(0.0739)	(0.0809)	(0.0647)	(0.0573)	(0.0515)	(0.0680)	(0.0692)	(0.0577)
lnamtpop (t-1)	0.667***	0.415**	0.460***	0.335*	0.0637	0.481***	0.422***	0.320*	0.0922	0.128
	(0.1430)	(0.1670)	(0.1750)	(0.1910)	(0.1530)	(0.1420)	(0.1270)	(0.1680)	(0.1710)	(0.1430)
lnenergyconspop (t-1)	0.484**	0.153	0.544**	0.948***	0.763***	0.345	0.359*	0.735***	1.323***	0.853***
	(0.2040)	(0.2400)	(0.2510)	(0.2740)	(0.2190)	(0.2110)	(0.1900)	(0.2510)	(0.2550)	(0.2130)
cityshare (t-1)	0.0181*	0.00585	0.00321	−0.0118	−0.0169*	0.0162	0.000615	−0.00548	−0.0173	−0.0238**
	(0.0092)	(0.0108)	(0.0113)	(0.0124)	(0.0099)	(0.0103)	(0.0093)	(0.0123)	(0.0125)	(0.0104)
Constant	8.442	−17.11	−11.71	10.74	115.5***	12.5	5.261	−10.27	30.05	34.82
	(35.2500)	(41.4000)	(43.2800)	(47.3400)	(37.8700)	(30.3700)	(27.3200)	(36.0800)	(36.6800)	(30.5900)
Observations	154	154	154	154	154	165	165	165	165	165
Pseudo R-sq	0.3311	0.2236	0.268	0.2899	0.3433	0.38	0.2489	0.240	0.2643	0.3539

Notation. Hereinafter *** indicates 1% significance level, ** indicates 5% significance level, * indicates 10% significance level. Standard errors are indicated in parentheses. Dummy variable for 2020 is included, but not reported.

Source: Authors' calculations

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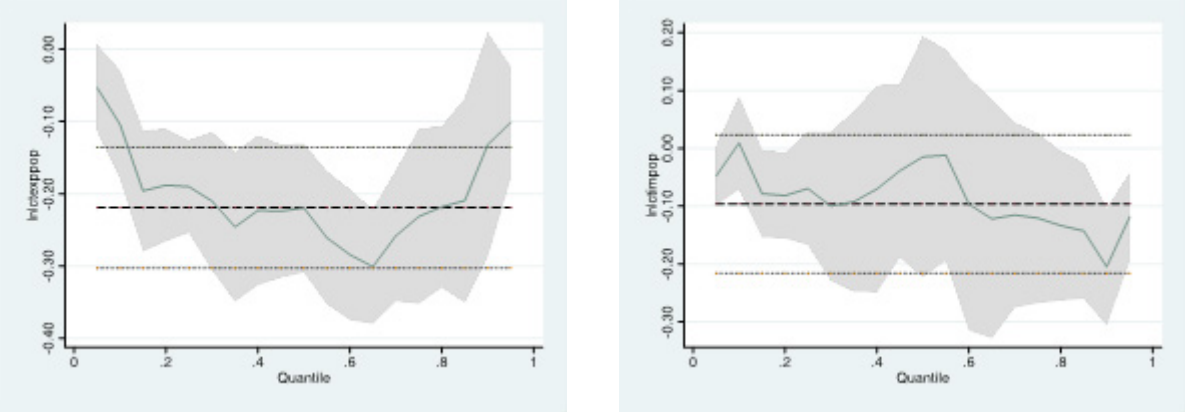

Figure 3. *Impact of LCGs Exports (Left) and Imports (Right) on Fuel Combustion Emissions Pollution in Russian Regions: Quantile Regression Results*

Source: Compiled by the authors based on own calculations

Conclusion

The spread of sustainable development goals is increasingly reflected in the growing contribution of low-carbon goods (LCGs) to global trade. However, this growth remains gradual, as the global economy continues to rely heavily on traditional energy sources, particularly coal. As this study has shown, LCG trade exhibits significant variation across Russian regions. Some regions are actively engaged in both exporting and importing these goods, while others show minimal involvement. This is an important finding, reinforcing the existing evidence of profound inequalities among Russian regions in their ability to adopt advanced technologies and develop innovation capacities. Such disparities are apparent both in the availability of innovative solutions on the supply side and the demand for them.

Our analysis reveals a non-linear relationship between LCG export intensity and emissions reduction, following a U-shaped pattern. When the level of LCG exports is relatively low, its impact on emissions reduction is insufficient, likely due to weak external effects. However, when export intensity is high, the correlation with emissions reduction diminishes, possibly due to regional economic barriers or a lack of sufficient incentives for widespread adoption of technologies that could significantly reduce emissions. These findings indicate that simplistic policy approaches aimed at equalizing technological distribution across regions might overlook the complexities of regional economic dynamics.

Rather than focusing solely on uniform technological dissemination, a more effective approach to industrial policy would be to raise the performance of lagging regions by transferring best practices from the leading ones. At the same time, it is crucial to continue fostering the development of advanced regions by supporting both the demand for efficient technological solutions and the identification and prioritization of promising technologies on the supply side. Encouraging regions that are already ahead in LCG adoption to push further, while ensuring that regions falling behind have access to these advancements, can help reduce the technological gap.

Our study also highlights that LCG imports can significantly reduce emissions in regions where these emissions are particularly high. This is another critical insight for industrial policy, as it underscores the cumulative effect of importing LCG technologies. Once a certain threshold is crossed, these imports can begin to have a measurable impact on reducing fuel combustion emissions. Therefore, from the perspective of sustainable development, reducing barriers to the importation of advanced low-carbon technologies and equipment—currently not produced domestically—becomes imperative.

Tax incentives for companies that invest in high-cost, cutting-edge foreign LCG technologies would serve as an effective tool to stimulate demand. This is especially important as global competition intensifies over access to the best foreign solutions, while countries simultaneously seek to protect their own leading technologies from being exported. Establishing clear mechanisms for international cooperation in the low-carbon technology sector is crucial to ensure that Russian in-

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dustries can access these advanced solutions. Collaborative frameworks could be explored to facilitate technology transfer, helping domestic firms integrate foreign expertise and overcome regional technological stagnation.

At the same time, while protecting domestic manufacturers from foreign competition can be useful in the early stages of technological development, such protection should not become a long-term strategy. It is essential to encourage competition in order to promote knowledge exchange and ensure that Russian low-carbon technologies remain globally competitive. Domestic producers will benefit from being exposed to international standards and innovation, which can help them enhance their own competitiveness.

Furthermore, targeted support for research and development (R&D) in regions with high potential for LCG innovation could stimulate the emergence of new solutions. Public-private partnerships, alongside state-backed grants and incentives for technological advancement, will be key to closing the technological gap between Russia's regions. In addition, investments in infrastructure that supports LCG adoption, such as specialized transportation systems for renewable energy technologies, could enhance regional participation in global LCG trade.

In conclusion, addressing both the supply and demand challenges of LCG trade will require a multifaceted approach. Supporting lagging regions, fostering innovation in leading ones, and encouraging international collaboration will not only reduce regional inequalities but also position Russia to play a more prominent role in the evolving global low-carbon economy.

Appendix 1

Top 10 positions of Russian LCGs export by share in gross exports from 2016–2021

HS Code Description	Relation to Low Carbon Goods and Technology	The share in the gross export of LCGs of Russia in 2016-2021
Heat exchange units, whether or not electrically heated	Essential for energy-efficient heating and cooling systems, including heat pumps and waste heat recovery systems, which reduce energy consumption and emissions.	2.1%
Measuring/checking instruments, apparatus, and machines	Critical for monitoring and optimizing the performance of low carbon technologies, such as renewable energy installations, smart grids, and energy-efficient processes, ensuring accurate data for improving efficiency and reducing emissions.	1.6%
Boards, panels, consoles, desks, cabinets, and other bases equipped with two or more apparatus for electric control or distribution of electricity	Key for managing and optimizing electricity distribution in renewable energy systems (solar, wind), smart grids, and energy storage systems, enhancing the efficiency and reliability of low carbon energy solutions.	1.5%
Parts of nuclear reactors	Vital components for nuclear reactors, which provide a significant source of low carbon energy by generating electricity without direct carbon emissions.	1.1%
Other machines and mechanical appliances, including electric wire coil-winders, and machines for mixing, kneading, crushing, grinding, screening, etc.	Support the manufacturing and processing of components used in renewable energy technologies, electric motors, batteries, and other low carbon solutions, contributing to the production and development of sustainable technologies.	0.9%
Parts and accessories of the articles of 90.13	Important for maintaining and enhancing the performance of optical instruments and appliances used in low carbon technologies, such as precision measurement devices in renewable energy and energy efficiency applications.	0.7%
Automatic regulating/controlling instruments and apparatus, not elsewhere specified in 90.32	Crucial for the automated regulation and control of systems in renewable energy installations, smart grids, and energy-efficient buildings, ensuring optimal performance and energy savings.	0.7%
Aluminum casks, drums, cans, boxes, and similar containers, excluding those for compressed/liquefied gas, with capacity not exceeding 300 liters	Used for the safe and efficient storage and transportation of materials, including chemicals and components for renewable energy technologies, reducing environmental impact through recyclability and lightweight construction.	0.6%

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HS Code Description	Relation to Low Carbon Goods and Technology	The share in the gross export of LCGs of Russia in 2016-2021
Slag wool, rock wool, and similar mineral wools, in bulk/sheets/rolls	Used as insulation materials in buildings and industrial processes, improving energy efficiency by reducing heat loss and energy consumption, thus lowering carbon emissions.	0.6%
AC generators (alternators), of an output greater than 750 kVA	Key components in large-scale renewable energy systems, such as wind and hydroelectric power plants, converting mechanical energy into electrical energy efficiently, supporting the generation of low carbon electricity.	0.5%

Source: Authors' calculations

Appendix 2

Top 10 positions of Russian LCGs import by share in gross imports from 2016–2021

HS Code Description	Relation to Low Carbon Goods and Technology	The share in the gross import of LCGs of Russia in 2016-2021
Machinery for liquefying air or other gases, whether or not electrically heated	Supports air separation processes critical for renewable energy production, such as manufacturing components for wind turbines, and for carbon capture and storage (CCS) technologies.	15.3%
Boards, panels, consoles, desks, cabinets, and other bases equipped with two or more apparatus for electric control or distribution of electricity	Essential for the efficient control and distribution of electricity in renewable energy systems (solar, wind), smart grids, and energy storage systems, enhancing the reliability and efficiency of low carbon technologies.	9.0%
Other machines and mechanical appliances, including electric wire coil-winders, and machines for mixing, kneading, crushing, grinding, screening, etc.	Crucial for manufacturing and processing components used in renewable energy technologies, such as electric motors for wind turbines, electric vehicles, and batteries, contributing to the development and production of low carbon solutions.	7.9%
Filtering or purifying machinery and apparatus for gases, other than intake air filters for internal combustion engines	Vital for reducing greenhouse gas emissions in industrial processes, supporting clean air initiatives, and enabling carbon capture and storage (CCS) technologies, which are integral to low carbon strategies.	3.6%
Parts of the filtering or purifying machinery and apparatus of HS code 8421 (excluding centrifuges, including centrifugal dryers)	Support the maintenance and efficiency of gas filtering and purifying systems, which are crucial for emissions reduction and air quality improvement in low carbon industrial applications.	2.6%
Gears and gearing (excluding toothed wheels, chain sprockets, and other transmission elements presented separately); ball or roller screws; gearboxes, etc.	Key components in renewable energy technologies, such as wind turbines and electric vehicles, ensuring efficient power transmission and mechanical performance, thereby supporting the shift to low carbon energy and transportation systems.	2.6%
Distilling/rectifying plant, whether or not electrically heated	Used in the production of biofuels and other renewable energy sources, contributing to the diversification of low carbon energy options and reducing reliance on fossil fuels.	2.5%
Parts of other gas turbines of HS codes 8411.81 and 8411.82	Utilized in gas turbines that can run on renewable biofuels or be integrated with renewable energy systems, thereby supporting low carbon power generation solutions.	2.3%
Electric accumulators, including separators therefor, whether or not rectangular (including square), lead-acid, of a kind used for starting piston engines	Important for energy storage in renewable energy systems, including solar and wind power installations, and for electric vehicles, facilitating the use and integration of low carbon technologies by providing reliable energy storage solutions.	2.3%
Measuring or checking instruments, apparatus, and machines	Essential for monitoring and optimizing the performance of low carbon technologies, including renewable energy installations and smart grids, ensuring efficient operation and accurate measurement of emissions and energy consumption.	2.2%

Source: Authors' calculations

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National adaptive social well-being index for measuring regional disparities in Kazakhstan

ABSTRACT
Relevance. The well-being of citizens is a key focus of national policies worldwide. Kazakhstan, however, is characterized by significant regional disparities in social well-being, which necessitates targeted programs and investments to improve conditions in less developed areas.
Research Objective. This study aims to develop a national adaptive social well-being index to evaluate and spatially map the regions of Kazakhstan.
Data and Methods. The methodology included identifying indicators through a literature review and regional data, conducting an expert survey to weight them, and creating a social well-being index. A spatial analysis was then used to calculate the index for each region.
Results. The social well-being index shows significant disparities across regions. Astana, Almaty, and Atyrau demonstrate strong social welfare, driven by economic growth and advanced social infrastructure. In contrast, Karaganda, Pavlodar, and Shymkent show lower social welfare, highlighting the need for targeted interventions and investments.
Conclusion. The findings offer valuable insights for policymakers to design strategies for sustainable socioeconomic growth in Kazakhstan. The proposed index can help national and regional authorities monitor social well-being.

KEYWORDS
social well-being; regional disparities; adaptive index; well-being index, measuring well-being, spatial development, socio-economic development

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Национальный адаптивный индекс социального благополучия для измерения региональных различий в Казахстане

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АННОТАЦИЯ

Актуальность. Благосостояние наций является краеугольным камнем национальной политики во всем мире. Признание различий в социальном благосостоянии среди регионов Казахстана требует внедрения целевых программ и инвестиций для улучшения социального благосостояния в менее развитых областях.

Цель исследования. Данное исследование направлено на разработку национального адаптивного индекса социального благосостояния для оценки и пространственного картирования регионов Казахстана.

Данные и метод. Методология исследования включала определение индикаторов на основе литературного обзора и доступных региональных статистических данных, а также проведение экспертного опроса для выбора индикаторов и определения их весовых коэффициентов. Затем был построен интегральный индекс социального благосостояния для оценки регионов. В заключение был проведен пространственный анализ с расчетом индекса для каждого региона.

Результаты. Разработанный индекс социального благосостояния эффективно выявил значительные различия в социальном благосостоянии между регионами. Результаты показали, что города Нур-Султан и Алматы, а также Атырауская область демонстрируют высокий уровень социального благосостояния, характеризующийся сильным экономическим ростом и развитой социальной инфраструктурой. В то же время Карагандинская, Павлодарская и Шымкентская области показывают более низкий уровень социального благосостояния, что подчеркивает необходимость целевых вмешательств и инвестиций.

Выводы. Результаты исследования предоставляют политикам важные данные для разработки стратегий, способствующих устойчивому социально-экономическому росту по всему Казахстану, что может изменить политическую ситуацию в стране. Государственным и региональным властям рекомендуется использовать этот индекс для мониторинга ситуации.

КЛЮЧЕВЫЕ СЛОВА

социальное благосостояние; региональные различия; адаптивный индекс; индекс благосостояния; измерение благосостояния; пространственное развитие; социально-экономическое развитие.

БЛАГОДАРНОСТИ

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ДЛЯ ЦИТИРОВАНИЯ

Satybaldin, A. A., Moldabekova, A., Alibekova, G. Zh., Azatbek, T. A. (2024). National adaptive social well-being index for measuring regional disparities in Kazakhstan. *R-Economy*, 10(4), 391–409. doi: 10.15826/recon.2024.10.4.024

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衡量哈萨克斯坦地区差距的国家适应性社会福利指数

摘要

现实性：国家福祉是全世界国家政策的基石。认识到哈萨克斯坦各地区在社会福祉方面的差异，就需要引入有针对性的方案和投资，以改善欠发达地区的社会福祉。

研究目标：本研究旨在制定国家社会福利适应性指数，用于哈萨克斯坦各地区的评估和空间绘图。

数据与方法：研究方法包括根据文献综述和现有的地区统计数据确定指标，以及进行专家调查，以选择指标并确定其加权系数。然后，构建社会福利综合指数，对各地区进行评估。最后，通过计算各地区的指数进行空间分析。

研究结果：发达的社会福利指数有效揭示了不同地区之间社会福利的显著差异。结果显示，努尔苏丹市和阿拉木图市以及阿特劳州以强劲的经济增长和发达的社会基础设施为特征，社会福利水平较高。与此同时，卡拉干达州、巴甫洛达尔州和什姆肯特州的社会福利水平较低，这表明有必要进行有针对性的干预和投资。

结论：研究结果为政策制定者提供了重要数据，有助于他们制定促进哈萨克斯坦全境的社会经济可持续增长战略，从而改变该国的政治局势。鼓励国家和地区当局利用该指数来监测局势。

关键词

社会福祉；地区差异；适应指数；福祉指数；福祉测量；空间发展；社会经济发展。

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Introduction

The study of social well-being is crucial for shaping public policy in Kazakhstan, especially in light of global challenges. The socio-economic development of Kazakhstan's regions is influenced by a variety of external and internal factors. External challenges include the ongoing geopolitical and economic crisis, environmental issues, and the shift towards a digital and circular economy. Meanwhile, internal problems—such as the degradation of social, industrial, and transport infrastructure, declining living standards, rising unemployment, migration, and growing social tension—further complicate the socio-economic landscape. Given these complex dynamics, understanding the social consequences of economic policy has become a key focus for both scholars and policymakers. In this context, developing a national adaptive index of social well-being in Kazakhstan's regions is of significant theoretical, methodological, and practical importance.

In recent years, the concept of "social well-being" has emerged as an alternative to the traditional macroeconomic indicator of Gross Domestic Product (GDP). Researchers argue that while GDP has long been used to assess a nation's economic performance, it increasingly falls short in measuring overall well-being and development. GDP focuses solely on economic output without accounting for factors such as income distribution, environmental sustainability, or the quality of life of citizens (Fioramonti et al., 2019). Also, scholars note that GDP is insufficient to guide national development strategies, particularly at the regional level (Charles & D'Alessio, 2020). Other researchers pointed out conceptual issues regarding the use of GDP in measuring social welfare (Slesnick, 2019). They concluded that GDP, while useful for measuring overall production, cannot accurately reflect the social well-being of a society. The authors argue that qualitative factors, particularly those related to human development, play a crucial role in driving economic growth and influencing exports (Lukman et al., 2023). From a financial standpoint, evaluating social well-being is of significant scientific and practical importance to both researchers and policymakers. By using well-being indicators in policymaking, it becomes possible to establish a connection between social capital and well-being at the regional level (Calcagnini & Perugini, 2019).

In the international arena, social well-being is measured using the Social Progress Index (SPI), Genuine Progress Indicator (GPI), Global Liveability Index (GLI), Better Life Index (BLI), and Quality of Life Index (QoL). The Social Progress Index is one of the world's largest curated social and environmental data collections. It concentrates on the non-economic aspects of global social performance. The Genuine Progress Indicator considers a nation's well-being by incorporating environmental and social factors. The Global Liveability Index quantifies the challenges presented to an individual's lifestyle and standard of living in 173 cities worldwide. The Better Life Index is constructed with the OECD data on housing, income, jobs, community, education, environment, civic engagement, health, life satisfaction, safety, and work-life balance indicators. The Quality of Life Index measures the overall well-being of individuals by evaluating factors such as purchasing power, safety, healthcare, cost of living, property price to income ratio, and pollution levels across different countries.

Existing indices for measuring social well-being provide valuable insights but face significant challenges when applied across different regions, particularly in terms of data availability, complexity, and scalability. Many of these indices place considerable emphasis on non-economic or subjective factors, such as life satisfaction or cultural elements, which can undermine their consistency and hinder cross-country comparisons. Moreover, the data requirements for these indices often exceed what is available in certain regions, particularly in developing or rural areas. Additionally, most of these indices are designed for country-level analysis, making them difficult to apply in regional assessments within a single country. Many regions lack the detailed data on social and environmental indicators that these frameworks typically rely on. As a result, such indices are better suited for national rather than subnational assessments, limiting their utility for regional policymaking and local well-being evaluations. This highlights the need for a new index that integrates economic, living standards, education, healthcare, environmental, and infrastructural indicators. Such an index would offer a more balanced and objective approach to measuring well-being at both the national and regional levels, making it more adaptable and widely applicable.

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This study aims to develop a national adaptive social well-being index for evaluating, comparing, and spatially mapping the social well-being of Kazakhstan's regions. The index will be based on a range of indicators, including economic, living standards, education, health, migration, and environmental and infrastructural factors, using both statistical and survey data.

The research hypothesis is that regions with a significant share of the mining industry in their gross regional product (GRP) tend to have a higher social well-being index. The mining industry may be a key factor influencing social well-being in these regions, as Kazakhstan remains a resource-based country, with mineral resources (58%) and metals and ores (18%) comprising the majority of its exports in 2022, according to national statistics.

The study is structured as follows: The first section provides a literature review of the concept of social well-being. The second section outlines the methodology, including the derivation of the formula, the indicator system, data sources, weighting method, and research process. The third section presents the primary empirical results, followed by a discussion in the fourth section. The study concludes with insights and recommendations for further research.

Theoretical framework

Social well-being is a multidimensional concept analysed within the social welfare and social well-being framework, intersecting with economics, sociology, and psychology. Researchers use mathematical, econometric, statistical, and empirical data to examine various aspects of social well-being. As Zahra et al. (2014) noted, social well-being encompasses economic and financial factors as well as social and environmental issues.

The concept of social well-being encompasses various aspects that reflect both individual and collective quality of life in society. Iacus et al. (2022) introduced social well-being as a daily measure, examining multiple dimensions of personal and social life, and comparing it to other well-being and health indicators. This approach suggests that environmental and health conditions can influence the perception of well-being, as captured by social well-being metrics. Contradictions or interesting insights arise when considering these measures within the broader context of sustainable human development indices (Iacus et al., 2022). Strezov et al. (2017) analyzed various indices for measuring sustainable development and noted that only a few integrated all three dimensions—economic, environmental, and social—highlighting the complexity and multifaceted nature of such measurements.

Income, social spending, and grants positively influence regional well-being through various mechanisms. Increased income enables individuals to access better healthcare, education, and living conditions, contributing to higher life satisfaction and well-being (Boyce et al., 2013). Social spending on welfare programs, healthcare, and education reduces poverty and inequality, fostering a more inclusive society with higher levels of happiness and stability (Livingston et al., 2022).

Local indices of well-being have been developed for individual countries. One such example is the QUARS index, created by Segre et al. (2011), which stands for "Regional Quality of Development" in Italian. The QUARS index uses 41 indicators across seven categories: environment, economy and labor, law and citizenship, education and culture, participation in the school system and quality of structures, public education, cultural activities, health, gender equality, and democratic participation.

Charles and D'Alessio adapted the Social Progress Index (SPI) to evaluate and rank Peru's regions using Data Envelopment Analysis (DEA). Their regional SPI highlights the importance of addressing critical gaps and leveraging strengths to help individuals achieve their full potential. The study assessed social progress across three dimensions: 1) basic human needs (nutrition, primary health care, safe drinking water, adequate housing, and community safety); 2) well-being essentials (access to primary education, information, healthy living conditions, and environmental quality); and 3) opportunities (individual rights, personal freedom, tolerance, and access to higher education for skill development) (Charles & D'Alessio, 2020).

Long and Ji applied the Genuine Progress Indicator (GPI) to evaluate social well-being across 31 Chinese provinces, emphasizing the need to assess economic growth quality for sustainable development planning. The study incorporated diverse indicators: economic factors like personal consumption expenditure, durable consumer services, and net capital gains; environmental dimensions such as changes in wetlands and forests; and

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social factors including volunteer work, non-defense public spending on education and health, and public infrastructure services. Other indicators included income inequality, water pollution, resource depletion, crime and divorce rates, and health and education spending (Long & Ji, 2019).

Quantitative methods play a crucial role in measuring social well-being. Glazyrina et al. (2021) applied simulation modeling and experimental planning theory to assess a region's social well-being using indicators such as gross regional product (GRP), population size, average monthly income, and consumer goods costs. Additionally, Data Envelopment Analysis (DEA) was used to evaluate social well-being in rural areas, incorporating inputs like wage, material, and administrative costs, and outputs such as the number of households and total employment days (Singh, 2016).

The literature includes many studies on factors affecting social well-being. Torres and Augusto (2020) explored the effects of digitalization and social entrepreneurship on national well-being, concluding that digitalization can improve well-being if supported by an effective education system, good governance, and a philanthropy-oriented financial system. Hassad de Andrade et al. (2022) studied the impact of the COVID-19 pandemic on food consumption habits, finding that individuals in countries with low levels of social welfare consumed more fast food during the pandemic compared to those in countries with higher levels of social welfare. These findings underscore the value of incorporating such factors into a social well-being index, as they reflect dynamic changes in well-being. Additionally, wealth inequality remains a critical measure, particularly in developing countries (Čižo et al., 2023).

While social well-being is often assessed at the macro level in international studies, the question as to how its practical utility can be enhanced at the local level requires regional analyses with tailored indicators and sub-indicators. Developing relevant tools for measuring social well-being at the regional level is essential for supporting timely and effective policy decisions. Existing approaches to regional social well-being measurement must also adapt to address challenges arising from digitalization.

Assessing social well-being requires a multidimensional approach, combining economic and social indicators such as income, health, education, relationships, employment, and neighborhood conditions (Livingston et al., 2022).

Seabela et al. (2024) investigate the determinants of income inequality in South Africa using the Vector Error Correction Model (VECM) and show a significant negative correlation between government spending on social grants and income inequality, suggesting that increased social grants improve social well-being by reducing income disparity. This study also highlights that population growth positively correlates with income inequality, indicating potential challenges for social well-being as the population expands without corresponding increases in resources and social services (Seabela et al., 2024).

Dermatis et al. (2024) assessed the quality of life (QoL) and mapped it for 27 EU countries, utilising composite criteria and the Geographical Information Systems (GIS) technology. Their research highlighted the complex and multidimensional nature of QoL, encompassing factors such as socio-economic environment, employment conditions, economic conditions, and health services (Dermatis et al., 2024).

These studies illustrate the complex interplay between economic policies, income inequality, and social well-being. Public policies that prioritize equitable income distribution, inclusive economic growth, and adequate social spending are essential for improving social well-being. Effective public policies that promote equitable income distribution, inclusive economic growth, and adequate social spending are crucial for enhancing social well-being.

Malkina (2015) applied simulation modeling and experimental design methods to assess social well-being at the regional level using indicators such as Gross Regional Product (GRP), population size, average monthly income, and consumer goods prices. In her later study of Russian regions, social well-being was evaluated using economic indicators like per capita nominal income and the distribution of actual income levels within regions, measured against the intra-regional Gini coefficient (Malkina, 2016). Bagstad & Shammin (2012) employed cluster analysis to examine regional well-being, incorporating factors such as economic conditions, labor markets, neighborhood relations, and environmental quality.

Social well-being can also be evaluated at the individual level across three dimensions: material well-being, which includes factors such as food,

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income, assets, housing, employment, access to services, natural resources, and environmental quality; relational well-being, which involves interactions with others, care and love relationships, relations with the state and social institutions, collective action, conflict and security, law, and cultural and political identity; and subjective well-being, which reflects personal perceptions of living conditions and quality of life (Britton & Coulthard, 2013).

The BBC well-being scale encompasses 24 questions covering quality of life, physical health, psychological health, and social relationships (Pontin et al., 2013).

In assessing regional subjective well-being at the individual level, Lawless and Lucas (2011) examined how life satisfaction levels correlate with economic factors (income, poverty level, employment, household expenses, home cost, mortgage/loans, rent), education level and occupational field, family status, and inclusion factors (types of illnesses, physical health, disability, obesity, causes of death, accidents, suicide).

The assessment of social well-being in relation to environmental and infrastructure parameters explores how elements of the built and natural environment affect human quality of life. Environmental factors such as air quality, green spaces, and climate change significantly influence social well-being. Green infrastructure (GI) is increasingly recognized as a key factor in promoting urban sustainability and enhancing well-being. Ko and Lee (2021) examined GI's effectiveness in improving social welfare through a Social Well-being Index. Using a random forest regressor, they identified significant links between GI types and variables such as population, employment rate, and air pollution, highlighting regional differences in GI's impact on social well-being. Similarly, Venkataramanan et al. (2019) reviewed the health and social well-being outcomes of GI in stormwater and flood management. While direct links between GI and physical or mental health outcomes remain limited, they found positive economic effects, such as higher property values, and noted mixed public perceptions of GI. Their findings stress the need for interdisciplinary research to better connect infrastructure design with tangible human outcomes. Both studies highlight the role of environmental quality in urban planning. For instance, poor air quality is linked to respiratory diseases and reduced life expectancy, negatively impacting social well-being. Well-planned infrastructure addressing these environmental challenges can play a crucial role in improving urban residents' quality of life.

Infrastructure plays a critical role in shaping social well-being by influencing various aspects of daily life, health, and overall quality of life. The built environment, which includes transportation systems, utilities, housing, and public spaces, directly affects individuals' physical and mental health, social interactions, and economic opportunities. Infrastructure development also influences economic opportunities and equity. Efficient transportation systems, for example, provide better access to jobs, education, and services, which can reduce socioeconomic disparities. However, inequitable infrastructure investment can exacerbate social inequalities, as marginalised communities may have less access to high-quality infrastructure and services (Ewing & Hamidi, 2015).

Infrastructure resilience to environmental challenges like climate change and natural disasters is another crucial aspect of social well-being. Resilient infrastructure can protect communities from the adverse effects of these challenges, ensuring continuity in essential services and enhancing community stability (Ahern, 2011).

In Kazakhstan, social well-being is analyzed to assess the population's quality of life by region (Kireyeva et al., 2023). The relationship between economic growth and income inequality remains a key issue in economic research, with significant implications for policy and regional development. Temerbulatova et al. (2024) provide a comprehensive analysis of this relationship, examining both the effects of economic growth on income inequality and vice versa across Kazakhstan's regions. Notably, Kazakhstan has not previously conducted integrated studies on its population's social well-being.

While various approaches to assessing social well-being provide valuable insights, they share critical limitations. Models that focus on income, social spending, and individual well-being often overlook environmental factors essential for long-term sustainability. Regional models and experimental forecasting methods rely on accurate data, which can lead to inaccuracies or gaps. Furthermore, many methods struggle with scalability when applying individual-level findings to broader or international contexts. To enhance their ef-

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Table 1

Indices of assessing social well-being: methods, indicators, and features

Index and disciplines	Method and indicators	Critique and features
Social Progress Index (SPI) Sociology, economics, healthcare, ecology	Measures social development across three categories: basic human needs, foundations of well-being, and opportunity. Utilizes 54 indicators categorized accordingly from statistical data and surveys. Indicators include basic needs (nutrition, water, housing, safety), well-being (education, health, environment), and opportunities (rights, freedom, tolerance).	egional adaptation helps identify strengths and weaknesses of regions, but measuring all parameters is labor-intensive (Charles & D'Alessio, 2020)
Genuine Progress Indicator (GPI) Economics, ecology, social sciences	Expands GDP by incorporating environmental and social costs and benefits. Calculated by subtracting negative factors (environmental and social) from growth indicators. Metrics include consumer spending, income inequality, water pollution, resource depletion, crime rates, volunteer work, healthcare, and education.	Including environmental and social costs makes the GPI more comprehensive, but it can be complex for international comparisons (Long & Ji, 2019)
Global Liveability Index (GLI) Urban studies, economics, sociology	Measures city livability using criteria like stability, healthcare, culture, environment, and education. Scores cities based on quantitative and qualitative data. Metrics include healthcare access, crime rates, education quality, and infrastructure.	Focuses primarily on urban centers, underrepresenting rural or smaller regions, which limits global applicability (EIU, 2024)
Better Life Index (BLI) Economics, sociology, public health	Developed by the OECD, it assesses well-being based on factors like housing, income, jobs, community, education, environment, civic engagement, and health. Data is drawn from a mix of survey responses and economic statistics.	Offers a user-driven approach to well-being measurement, but subjective weights complicate cross-country comparisons (OECD, 2021)
Quality of Life Index (QoL) Sociology, economics, ecology	Assesses well-being through multiple dimensions such as health, working conditions, and socio-economic environment. Based on survey data and statistical indicators. Metrics include socio-economic conditions, labor environment, economic status, and healthcare.	Provides a comprehensive analysis with multiple factors, though cross-country comparisons may remain challenging (Dermatis et al., 2024)

Source: compiled by the authors

fectiveness, future indices should tackle these issues by integrating environmental factors, enhancing data reliability, and creating scalable frameworks.

Indices for assessing social well-being focus on dimensions such as basic needs, economic growth, environmental sustainability, and subjective life satisfaction. The Social Progress Index (SPI)[1] and Quality of Life Index (QoL)[2] measure well-being through health, economic, and social indicators, though they can be resource-intensive and difficult to compare across regions. The Genuine Progress Indicator (GPI) emphasizes the inclusion of environmental and social costs, but face challenges in data availability and international applicability[3]. The Global Liveability Index (GLI) focuses on urban factors like healthcare, stability, and infrastructure, but its focus on cities limits its broader application[4]. The Better Life Index (BLI) emphasizes subjective life satisfaction and well-being across various dimensions like income and housing but can be difficult to standardize for global comparison due to user-driven customization[5]. While these indices offer valuable insights, they are constrained by data limitations, complexity, and scalability issues. A comparative assessment of these indices, including their disciplines, methods, indicators, and limitations, is presented in Table 1.

[1] Social Progress Imperative. Available at: https://www.socialprogress.org/ (Date of access: November 3, 2024)

[2] Numbeo. Available at: https://www.numbeo.com/quality-of-life/rankings_by_country.jsp (Date of access: November 3, 2024)

[3] Recipes for Wellbeing. Available at: https://www.recipes-forwellbeing.org/genuine-progress-indicator/ (Date of access: November 3, 2024)

[4] Economist Intelligence Unit. Available at: https://www.eiu.com/n/campaigns/global-liveability-index-2023/ (Date of access: November 3, 2024)

[5] OECD Better Life Index. Available at: https://www.oecdbetterlifeindex.org/ (Date of access: November 3, 2024)

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A comparison of various indices shows that, while some of these indices incorporate environmental and social costs, their practical utility is limited by a lack of standardization and challenges in comparing data across regions and countries. Many indices are region-specific, which makes generalization or international application challenging. The absence of comprehensive data on critical factors, such as environmental sustainability, further restricts our understanding of the relationship between social well-being, economic growth, and infrastructure development.

Additionally, subjective well-being measures, while useful for capturing individual perceptions, often overlook broader societal issues, like income inequality or environmental degradation, reducing the scope of some indices. To enhance their effectiveness, these indices need to address challenges related to data availability, simplify complex calculations, and integrate more comprehensive metrics that account for the interconnection between social, economic, and environmental factors.

In summary, social well-being is a multifaceted concept that encompasses personal, social, and work-related dimensions. It is part of a broader shift toward including diverse factors in measuring well-being and sustainable development. When selecting an approach for measuring social well-being, it's important to consider the economy's maturity (developed or developing) and local community conditions.

Social well-being reflects the efficiency and quality of the social system, as well as the competency of authorities in managing socio-economic processes. As our literature review has shown, assessment of social well-being at the regional level should include not only macroeconomic indicators but also social, infrastructural, and environmental factors.

Methods and data

Data from the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of Kazakhstan were used to analyze the social well-being across the country's regions. These data were analyzed using descriptive statistics and index methods. As shown in Figure 1, constructing the National Social Well-Being Index (NSWI) involved five stages of research.

1. The following indicators proposed by experts were included in the NSWI: Investments in Fixed Assets, Fund Coefficient (the ratio of the wealthiest 10% to the poorest 10%), Life Expectancy at Birth, and Length of Public Paved Roads. However, statistical data for the following indicators over the past five years could not be found: population indebtedness, levels of alcoholism and drug addiction, corruption (registered criminal corruption offenses), and suicidality (mortality from suicides).

2. To determine the significance level of each indicator, assessments were conducted by 45 experts using the Likert scale (June-July 2023). The experts were academics specializing in socio-economic development issues in Kazakhstan's regions. Consistency of responses was checked using Cronbach's Alpha coefficient in SPSS 25, revealing an average score of 0.88. This indicates a high level of agreement among experts regarding the significance of these factors, with environmental and social aspects receiving the most emphasis. The weighting coefficients of the indicators were calculated using formula (1):

$$m_i = \frac{1}{n}\sum_{i=1}^{n}\frac{h_{ix}}{\sum_{x=1}^{k} h_{ix}}, \quad (1)$$

where m_i is the weight coefficient of the i-th indicator; n is the number of indicators; h is the assessment of the expert on indicator i.

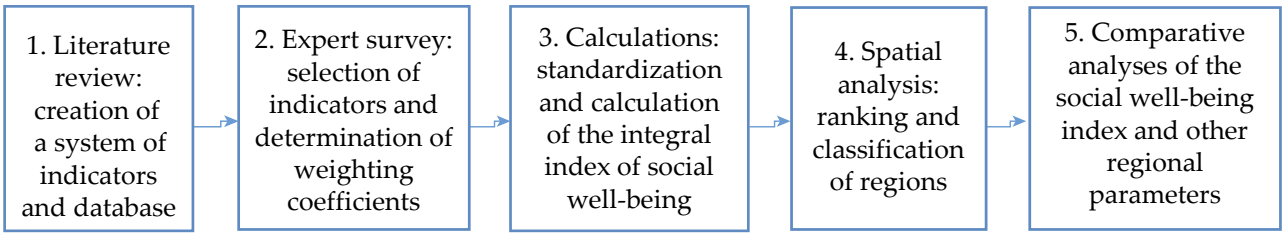

Figure 1. *Methodology for constructing the National Social Well-Being Index*

Source: compiled by the authors.

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Drawing on expert evaluations, we assigned weighting coefficients to each parameter. The highest coefficient (0.039) was given to Gross Regional Product per Capita and Maternal Mortality Rate (per 100,000 births), indicating their perceived significance by the experts. In contrast, the lowest coefficient (0.030) was assigned to the Overall Divorce Rate in Kazakhstan, suggesting it was considered less important or exhibited more variability in expert assessments. Other indicators, such as Investments in Fixed Capital, Enrollment Rates in Education (preschool and secondary), Infant Mortality, and Satisfaction with the Quality of Drinking Water, received a coefficient of 0.037, reflecting a consistent level of importance. Additionally, key parameters like Poverty Depth, Emissions of Pollutants (air, liquid, solid), and Life Expectancy showed coefficients around 0.036, demonstrating a stable evaluation across these areas. Detailed coefficients for each indicator are provided in Annex 1.

3. Furthermore, the collected statistical data were standardized using linear scaling, a method commonly employed in international practice, such as in the calculation of the UN Human Development Index. Data standardization was carried out using formulas (2) and (3), depending on whether the indicator positively or negatively impacts social well-being:

$$I_k = \frac{x - x_{\min}}{x_{\max} - x_{\min}} \quad I_k = 1 - \frac{x - x_{\min}}{x_{\max} - x_{\min}}, \qquad (2)$$

where I_k is value of the private index of the region's well-being, x is the estimated indicator, $x_{\max}$, $x_{\min}$ are the reference points (maximum and minimum values of the indicator for the period under study).

The same standardisation techniques were used to investigate and evaluate the status of sustainable development of selected Chinese provinces (Cai et al., 2023).

The weighting coefficients of the parameters were considered to determine the final index of social well-being for the regions. The calculated indices for each indicator are multiplied by their respective weighting coefficients, and the sum of the values for the economy, standard of living, education, health care, migration, environment, and infrastructure are used to determine the final index according to formula:

$$ISW = \sum_{i=7}^{n} I_i \cdot m_i, \qquad (3)$$

where ISW is the integral index of social well-being, I is the index for the i-parameter, m is the weight coefficient for parameter i.

4. After calculating the regional indices of social well-being, the regions were ranked based on the average index value using the following scale: 0.42–0.46 (low index), 0.47–0.49 (medium index), and 0.50–0.55 (high index). This scale was developed by dividing the range between the highest and lowest index values into three groups.

5. Finally, the regional values of the NSWI were analyzed in relation to regional parameters, such as population and economic structure, particularly the share of the mining industry in GRP, to test the hypothesis.

Results

Building on our literature review, we propose an Adaptive National Social Well-Being Index. Indicators from the National Statistics Bureau, along with those recommended by experts in the survey, were categorized into economic, living standards, education, healthcare, migration, environmental, and infrastructure factors (Table 2).

The final indicators of the National Social Well-Being Index (NSWI) consist of 28 metrics, organized into seven categories. The key parameters and indicators for Kazakhstan's regions are listed in Table 2. Data for these indicators, covering the period from 2018 to 2022, were sourced from the Bureau of National Statistics of Kazakhstan.

To provide an objective measure of social well-being and track regional development, calculations were conducted for 2018–2022 (see Table 3 below). The analysis of the social well-being index reveals significant regional disparities. On average, the highest index values were found in Atyrau region (0.54) and Astana city (0.55), reflecting a high level of social well-being. In contrast, Karaganda (0.42) and Pavlodar regions (0.43) recorded the lowest values, indicating lower levels of well-being. Notably, some regions, such as Aktobe, experienced sharp fluctuations in the index, with a significant drop to 0.30 in 2020, suggesting potential temporary economic or social challenges.

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Table 2

Main parameters and indicators of the National Index of Social Well-Being of Regions

Parameter	Indicator and Scale
Economic	Gross Regional Product per Capita, million tenge; Investments in Fixed Assets*, million tenge; Growth Rate of Average Per Capita Nominal Cash Income, %; Self-Employed in Unproductive Activities, number of people; Employees, number of people
Living Standard	Index of Real Cash Income (as a percentage of the corresponding period of the previous year); Share of Population with Income Below Subsistence Minimum, %; Fund Coefficient (ratio of the wealthiest 10% to the poorest 10%), times*; Poverty Depth, Life Expectancy at Birth, years*
Education	Gross Enrollment Ratio in Preschool Education; Gross Enrollment Ratio in Secondary Education; Gross Enrollment Ratio in Higher Education
Healthcare	Maternal Mortality Ratio (per 100,000 live births); General Mortality Rate (per 1000 people); Infant Mortality Rate (per 1,000 live births)
Migration	Crime Rate per 10,000 population; General Divorce Rate in Kazakhstan; Net Internal/External Migration Balance in Kazakhstan
Ecology	Emissions of Atmospheric Pollutants from Stationary Sources per Capita (without treatment); Emissions of Liquid and Gaseous Pollutants per Capita (without treatment); Emissions of Solid Pollutants per Capita (without treatment); Utilized Pollutants; Respondents' Satisfaction with Air Cleanliness (absence of emissions, smoke, dust, and dirt), based on a survey of the Bureau of National Statistics of Kazakhstan
Infrastructure	Length of Public Paved Roads per 1,000 square kilometres*; Respondents' Satisfaction with Drinking Water Quality, based on a survey of the Bureau of National Statistics of Kazakhstan; Level of Digital Literacy, %; Number of Fixed Internet Subscribers, thousand units

* These indicators were chosen following expert evaluation.

Source: compiled by the authors

Table 3

National Social Well-being Index of Kazakhstan's regions and its average value, 2018–2022

Region/year	2018	2019	2020	2021	2022	Average Index
Akmola	0,46	0,45	0,41	0,46	0,45	0,44
Aktobe	0,52	0,52	0,30	0,51	0,45	0,46
Almaty	0,49	0,50	0,38	0,55	0,51	0,49
Atyrau	0,59	0,57	0,37	0,57	0,61	0,54
West Kazakhstan	0,58	0,56	0,31	0,48	0,55	0,50
Zhambyl	0,52	0,48	0,37	0,44	0,49	0,46
Karaganda	0,42	0,37	0,49	0,43	0,39	0,42
Kostanay	0,44	0,43	0,39	0,49	0,49	0,45
Kyzylorda	0,48	0,51	0,30	0,48	0,60	0,47
Mangystau	0,46	0,51	0,30	0,35	0,53	0,43
Pavlodar	0,41	0,41	0,53	0,42	0,38	0,43
North Kazakhstan	0,46	0,47	0,34	0,49	0,58	0,47
Turkestan	0,48	0,57	0,43	0,42	0,47	0,47
East Kazakhstan	0,54	0,48	0,42	0,60	0,56	0,52
Astana city	0,57	0,61	0,44	0,56	0,57	0,55
Almaty city	0,57	0,57	0,46	0,58	0,52	0,54
Shymkent city	0,56	0,59	0,34	0,39	0,36	0,45
Mean	0,50	0,51	0,39	0,48	0,50	0,48

Source: Authors' calculations.

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Table 4

Grouping of regions by average values of the National Social Well-Being Index for 2018–2022

Group of Regions	Regions (Indices)
Regions with high NSWI	Astana City (0.55); Almaty City (0.54); Atyrau (0.54); East Kazakhstan (0.52); West Kazakhstan (0.50)
Regions with medium NSWI	Almaty (0.49); North Kazakhstan (0.47); Turkestan (0.47); Kyzylorda (0.47)
Regions with low NSWI	Aktobe (0.46); Zhambyl (0.46); Shymkent City (0.45); Kostanay (0.45); Akmola (0.44), Pavlodar (0.43); Mangystau (0.43); Karaganda (0.42)

Source: Compiled by the authors

Excluding the decline in the index during the 2020–2021 COVID-19 pandemic, regions such as Atyrau, Mangystau, North Kazakhstan, Kostanay, Almaty, and East Kazakhstan have shown stable growth in the NSWI. In contrast, regions like Shymkent, Almaty city, Aktobe, Pavlodar, and Akmola have experienced negative trends in their indicators, highlighting the need for additional measures to improve social and economic stability. It was observed that all regions saw a drop in the NSWI in 2020, primarily due to the global impact of the COVID-19 pandemic, which halted economic activity. However, by 2021, most regions had recovered quickly, with the only exception of Turkestan region, which showed a slow recovery compared to the others, possibly due to its larger population and higher population density.

This study categorizes regions into three groups based on their average NSWI scores: high (0.50–0.55), average (0.46–0.49), and low (0.42–0.46). The scaling of the National Social Well-Being Index (Table 3) shows that, apart from Astana and Almaty, only three regions—Atyrau, East Kazakhstan, and West Kazakhstan—achieve high NSWI values. Table 4 presents the grouping of regions by the average NSWI for 2018–2022. High social well-being regions, such as Astana, Almaty, Atyrau, East Kazakhstan, and West Kazakhstan, demonstrate strong economic activity and investment potential. Regions with average social well-being, including Almaty, North Kazakhstan, Turkestan, and Kyzylorda, have shown stable growth and investment in social sectors. Conversely, regions with low social well-being, such

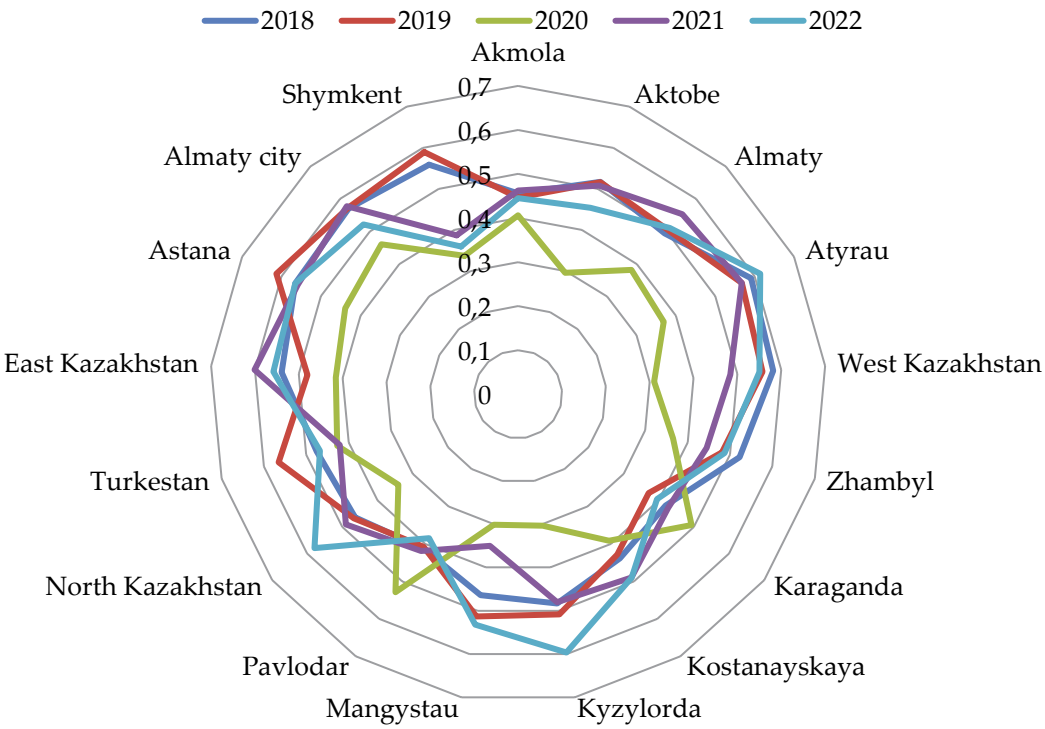

Figure 2. *Regions of Kazakhstan by the Social Well-Being Index in 2018–2022.*
Source: Authors' calculations.

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as Aktobe, Kostanay, Akmola, Zhambyl, Pavlodar, Mangistau, Karaganda, and Shymkent, require targeted interventions to improve their socio-economic conditions.

The situation remained largely unchanged in several regions throughout the whole given period (2018–2022) (Figure 2). It is important to note that the NSWI reached its lowest point in 2020 across nearly all regions due to the COVID-19 pandemic.

Values of the NSWI subindicators for 2022 are essential for analyses of the current situation in the regions of Kazakhstan (Annex 2). They reflect key socio-economic dimensions through the following subindicators:

Economic Indicators: The highest economic score is in Atyrau (0.74), reflecting its strong economic base due to oil production. Mangistau (0.49) and Pavlodar (0.44) also rank high, likely due to their industrial bases. The lowest economic score is in Almaty region (0.22), suggesting challenges despite its importance as a financial hub.

Life Quality Indicators: Atyrau (0.89) and Zhambyl (0.72) rank highest in life quality, indicating better access to services, social stability, and living conditions. Karaganda (0.53) and Turkestan (0.53) are in the middle, while Akmola (0.40) and Astana (0.42) show lower scores.

Education Indicators: North-Kazakhstan (0.96) stands out with a remarkably high score in education, which may indicate a focus on educational resources and infrastructure. Regions like Karaganda (0.20) and Turkestan (0.10) score quite low, highlighting challenges in educational access and quality.

Healthcare Indicators: Almaty city (0.87) and East-Kazakhstan (0.75) demonstrate strong healthcare systems, while North-Kazakhstan (0.12) and Astana (0.27) lag significantly behind, suggesting healthcare access and quality concerns.

Migration: Shymkent city (0.72) and West-Kazakhstan (0.58) have high migration scores, which may be tied to economic opportunities and living conditions attracting more residents. Kostanai (0.25) and Pavlodar (0.23) show lower migration rates, indicating less population movement or attractiveness.

Environmental Indicators: Kyzylorda (0.99) and Atyrau (0.83) have the highest scores for environmental indicators, possibly due to effective environmental policies or lower industrial pollution. Pavlodar (0.31) and Karaganda (0.38) have some of the lowest scores, likely reflecting environmental challenges related to heavy industries.

Infrastructure Indicators: Astana city (0.72) and Karaganda (0.68) lead in infrastructure, demonstrating strong transportation, energy, and urban infrastructure. Turkestan (0.33) and Pavlodar (0.29) score lower, indicating weaker infrastructure development.

This analysis highlights regional disparities in Kazakhstan, with some regions excelling in specific areas but facing significant challenges in others. Atyrau leads in economic strength and quality of life but struggles with infrastructure; Pavlodar performs well in education but faces environmental and infrastructure issues; North Kazakhstan excels in education but underperforms in healthcare and migration; and the cities of Astana, Almaty, and Shymkent show mixed results, excelling in infrastructure and healthcare but needing improvements in economic and environmental areas.

The specialization of regions and their contributions to the national economy are closely linked to the socio-economic development of these areas, influencing the social well-being of their residents. While the mining sector plays a crucial role in regional economic indicators, its impact on social well-being remains unclear. To test this hypothesis, we compare the regions' NSWI with the share of the mining industry in their GRP (Table 5).

This table provides an overview of various regions in Kazakhstan, comparing their economic indicators and NSWI across different sectors. Atyrau (0.55) is dominated by mining (38.4%), with small contributions from agriculture (1%) and moderate manufacturing (5.3%). The region's high NSWI is driven by wealth from the oil and gas industry, despite limited diversification. East Kazakhstan (0.52) has a more balanced economy, with mining (15.1%), agriculture (8.9%), and significant manufacturing (23%), supporting a stable and high NSWI. West Kazakhstan (0.50), another resource-rich area, relies heavily on mining (38.9%) but has smaller agricultural and manufacturing sectors, contributing to relatively high social well-being.

Almaty region is largely dependent on agriculture (15.8%) and manufacturing (24.3%), with little mining activity, resulting in moderate social well-being. Kyzylorda (0.47) also depends on mining (21.3%), agriculture (6%), and manufacturing (6.1%), but its focus on primary sectors limits higher NSWI scores. In North Kazakhstan

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Table 5

Economic profile of regions of Kazakhstan in 2022

Regions	Primary sector, 2022		Secondary sector, 2022	Average NSWI for 2018-2022
	Mining industry, % in GRP	Agricultural industry, % in GRP	Manufacturing industry, % in GRP	
NSWI – 0,5–0.55 (high)				
1. Astana City	–	–	16,8	0,55
2. Atyrau	38,4	1	5,3	0,54
3. Almaty City	–	–	7,9	0,54
4. East Kazakhstan	15,1	8,9	23	0,52
5. West Kazakhstan	38,9	4,2	4,9	0,5
NSWI – 0.47–0.49 (medium)				
6. Almaty	0,3	15,8	24,3	0,49
7. Kyzylorda	21,3	6	6,1	0,47
8. North Kazakhstan	7,5	18,7	8	0,47
9. Turkestan	8,8	6	29	0,47
NSWI – 0.42–0.46 (low)				
11. Aktobe	19,9	6,2	11,8	0,46
10. Zhambyl	2,9	11,2	15,1	0,46
12. Kostanay	12,5	12,5	19,5	0,45
13. Shymkent City	0,04	–	25,7%	0,45
14. Akmola	3,9	16,5	24,3	0,44
15. Pavlodar	0,2	27,9	10,6	0,43
16. Mangystau	44,5	0,8	4,4	0,43
17. Karaganda	13,1	3,8	31,4	0,42

Source: Compiled by the authors

(0.47), agriculture (18.7%) dominates, while mining (7.5%) and manufacturing (8%) contribute less, leading to moderate social well-being. Turkestan (0.48) benefits from strong manufacturing (29%) but faces challenges in other areas, giving it a medium NSWI.

Aktobe (0.46) relies on mining (19.9%), agriculture (6.2%), and manufacturing (11.8%), but its lower NSWI reflects challenges in economic or social infrastructure. Zhambyl (0.46) has a balanced industrial base with agriculture (11.2%) and manufacturing (15.1%) as key sectors, while mining plays a minor role (2.9%), contributing to moderate social well-being. Kostanay (0.45) is fairly diversified with agriculture (12.5%) and manufacturing (19.5%) but faces socio-economic challenges, resulting in a lower NSWI.

Akmola (0.45) benefits from developed agriculture (16.5%) and manufacturing (24.3%), but struggles with low social well-being, possibly due to infrastructure or public service issues. Pavlodar (0.43) is heavily focused on agriculture (27.9%) with limited manufacturing (10.6%) and minimal mining, which affects its NSWI. Mangystau (0.43), dominated by mining (44.5%), has low diversification into agriculture (0.8%) and manufacturing (4.4%), keeping its NSWI low despite mining's economic output. Karaganda (0.42), reliant on manufacturing (31.4%) and mining (13.1%), faces socio-economic challenges linked to an over-reliance on these industries, leading to a lower NSWI.

Thus, our analysis has refuted the initial hypothesis, which suggested that regions with a large share of mining in their GRP would have a higher NSWI. While resource-rich regions like Atyrau and West Kazakhstan score higher due to the economic strength derived from mining, despite limited diversification, regions with a more balanced industrial structure, such as East Kazakhstan and Almaty, tend to have higher NSWI. This highlights the benefits of industrial diversification. In conclusion, regions with strong industrial bases and economic diversification sup-

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port higher social well-being, while areas overly reliant on a single sector, such as mining or agriculture, tend to have lower NSWI scores. For instance, agriculture-dependent regions like Pavlodar and North Kazakhstan exhibit lower NSWI, reflecting the limitations of economies dominated by agriculture with less industrial or mining activity.

Discussion

The findings of this study, along with previous research, contribute to the understanding of regional social well-being by emphasizing the role of various factors in improving community welfare. Assessing social well-being is complex, highlighting the need for a systematic approach to understand its dynamic nature and impact on quality of life (Greblikaitė et al., 2018). Our study revealed significant regional variations in Kazakhstan's social well-being, with NSWI ranging from 0.42 in Karaganda (lowest) to 0.55 in Astana city (highest). These disparities are linked to differing economic activities, investment policies, and socioeconomic conditions. The results support the need for targeted economic and social programs to address regional inequalities in well-being. Additionally, the relevance of monetary policy strategy for human resource development is affirmed by earlier research (Kurniasih, 2023). The research by Pérez et al. (2024) provides valuable insights into the interplay between social programs, socioeconomic variables, and poverty. While social programs offer temporary relief, their long-term impact on poverty reduction is limited. Investments in education, infrastructure, and economic stability are essential for creating sustainable solutions to poverty. Access to education and healthcare services emerged as critical factors in improving social well-being and reducing poverty. Higher education correlates with better job opportunities and income levels, reducing poverty risk. Comprehensive policies focused on improving educational outcomes and healthcare access can significantly reduce poverty in the regions (Pérez et al., 2024).

Economic growth does not necessarily lead to high social welfare, as exemplified by regions with high GRP but low social well-being indices, such as Pavlodar and Karaganda regions. This underscores the necessity for more equitable resource distribution and improved social services.

Conclusions

The adapted National Social Well-Being Index (NSWI) for Kazakhstan serves as a comprehensive tool for evaluating regional disparities in social and economic conditions. This index is constructed using 28 indicators across seven parameters, including economic performance, living standards, education, healthcare, migration, environmental quality, and infrastructure. The findings from 2018 to 2022 highlight significant regional differences: Atyrau and Astana consistently rank highest in NSWI values due to robust economic activity and investment appeal, whereas regions like Karaganda and Pavlodar exhibit lower scores, indicative of persistent economic and social challenges.

Our analysis brings to light a clear trend: regions with diversified economies, like East Kazakhstan and Almaty, tend to have higher social well-being, while those dependent on a single sector, particularly mining or agriculture, show lower scores. Resource-rich regions, such as Atyrau and West Kazakhstan, achieve high NSWI scores due to strong oil and gas industries, but their lack of diversification limits broader social progress. In contrast, regions like Aktobe and Pavlodar, with lower NSWI scores, face challenges from reliance on a narrow economic base, impacting infrastructure, social services, and environmental quality.

Economic diversification, especially in the industrial sector, is key to improving social well-being. Regions in Kazakhstan affected by the COVID-19 pandemic saw significant drops in their NSWI scores in 2020, but most recovered quickly by 2021. The NSWI framework serves as a valuable policy tool to identify areas needing targeted interventions for greater social and economic stability. The study highlights the importance of equitable resource distribution and investment in social infrastructure, healthcare, and environmental protection, particularly in industrial or remote areas. Addressing social well-being disparities requires tailored policies to promote balanced and inclusive growth across Kazakhstan.

Nonetheless, the study has certain limitations, including data availability and quality, reporting inconsistencies, and subjective expert weighting, all of which could influence the accuracy of the index. A static index may also fall short of capturing the dynamic aspects of social well-being, and there might be a delay between policy implemen-

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tation and observable outcomes. Future research should strive to refine indicators, integrate more comprehensive data, and investigate the complex interactions shaping social well-being.

In summary, while some regions have made progress in social well-being, significant disparities remain. Policymakers must address these challenges with targeted interventions to promote equitable development, ensuring all regions contribute to Kazakhstan's prosperity and resilience. To reduce regional disparities, focused programs and investments are needed to improve living standards in less developed areas. High-performing regions can serve as models for balanced socioeconomic growth, guiding improvements in lower-performing regions.

Appendix 1

Weighting coefficients of the indicators of the National Index of Social Well-Being

№	Indicators	Weighting coefficients
1	Gross regional product per capita	0,039
2	Investments in fixed capital	0,037
3	Growth rate of average per capita nominal monetary income of the population	0,037
4	Self-employed workers, number of people (productively/unproductively employed)	0,036
5	Employees, number of people	0,033
6	Real monetary income index (in % of the corresponding period of the previous year)	0,037
7	Share of population with incomes below the subsistence minimum	0,038
8	Ratio of funds between the top 10% and bottom 10% of the population, times	0,032
9	Poverty depth	0,036
10	Gross enrollment rate of children in preschool education and training	0,037
11	Gross enrollment rate of secondary education	0,037
12	Gross enrollment rate of higher education	0,036
13	Maternal mortality rate (per 100,000 births)	0,039
14	Overall mortality rate (per 1,000 people)	0,037
15	Infant mortality rate (per 1,000 births)	0,037
16	Life expectancy at birth	0,036
17	Crime rate*per 10,000 population	0,036
18	Overall divorce rate in Kazakhstan	0,030
19	Balance of internal/external migration of the population in Kazakhstan	0,033
20	Emissions of air pollutants from stationary sources, per capita (without purification)	0,036
21	Emissions of liquid and gaseous pollutants, per capita (without purification)	0,035
22	Emissions of solid pollutants, per capita (without purification)	0,036
23	Disposed of pollutants	0,034
24	Respondents' opinions on satisfaction with air purity (absence of emissions, smoke, dust and dirt)	0,035
25	Length of public paved roads, kilometers per 1000 square kilometers	0,036
26	Respondents' satisfaction with the quality of drinking water	0,037
27	Proportion of housing with water supply, %	0,036
28	Number of fixed-line Internet subscribers, thousand units	0,034
	Total	1,000

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Appendix 2

Sub-indices of the National Index of Social Well-Being in the regions of Kazakhstan for 2022

Region	1.Economy	2.Life quality	3.Education	4.Healthcare	5.Migration	6.Environment	7.Infrastructure
Akmola	0,34	0,40	0,40	0,52	0,38	0,65	0,37
Aktobe	0,38	0,57	0,28	0,53	0,41	0,59	0,50
Almaty	0,22	0,65	0,41	0,39	0,42	0,74	0,56
Atyrau	0,74	0,89	0,37	0,56	0,48	0,83	0,35
West-Kazakhstan	0,40	0,68	0,39	0,48	0,58	0,70	0,48
Zhambyl	0,38	0,72	0,34	0,61	0,45	0,77	0,35
Karaganda	0,35	0,53	0,20	0,32	0,38	0,38	0,68
Kostanai	0,41	0,68	0,48	0,21	0,25	0,55	0,35
Kyzylorda	0,40	0,76	0,45	0,62	0,36	0,99	0,35
Mangistau	0,49	0,55	0,53	0,73	0,34	0,69	0,30
Pavlodar	0,44	0,69	0,63	0,44	0,23	0,31	0,29
North-Kazakhstan	0,43	0,52	0,96	0,12	0,48	0,62	0,38
East-Kazakhstan	0,41	0,44	0,62	0,75	0,42	0,75	0,34
Astana city	0,40	0,42	0,33	0,27	0,42	0,66	0,72
Almaty city	0,37	0,67	0,40	0,87	0,55	0,73	0,45
Shymkent city	0,40	0,44	0,34	0,74	0,72	0,59	0,60
Turkestan	0,38	0,53	0,10	0,59	0,27	0,74	0,33
Mean	0,41	0,59	0,43	0,51	0,42	0,66	0,44

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Unlocking the potential of inter-municipal cooperation

ABSTRACT
Relevance. Inter-municipal cooperation is an effective tool for addressing resource deficits faced by municipalities, and its importance has grown in today's context of socio-economic instability. However, the success of such cooperation largely depends on a careful selection of partners, which raises the question of how the strength of ties between municipalities impacts their ability to collaborate effectively.
Research objective. The aim of this study is to explore how the spatial characteristics of interdependence between municipalities influence their interactions and cooperation.
Data and methods. The research draws on official statistical data from Russia's Federal State Statistics Service (Rosstat), as well as information from investment passports and municipal socio-economic development strategies. The study employs spatial correlation methods, cartographic analysis, and general research techniques, including analysis and synthesis.
Results. The inter-municipal relationships in Sverdlovsk Region are highly uneven, with significant disparities in the level of involvement across different areas. These relationships are predominantly concentrated around the region's administrative center and its neighboring municipalities, while the northern and eastern parts exhibit the weakest connectivity. Municipalities in the Ekaterinburg urban agglomeration are the most active participants in joint projects, whereas those in the southwestern part of the region show less involvement. The northern and eastern areas, in particular, demonstrate minimal engagement in forming partnerships with other municipalities, highlighting a stark regional imbalance.
Conclusions. The study confirms a strong link between the interdependence of municipalities and the extent of their cooperation. Factors such as territorial and socio-economic proximity play a key role, but additional drivers, such as national or regional policies, also significantly influence inter-municipal collaboration. Interestingly, a lack of resources among potential partners does not appear to impede cooperation.

KEYWORDS
interdependence of municipalities, inter-municipal cooperation, municipality, location, spatial analysis, development strategy, inter-municipal project, regional policy, management of spatial transformations

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Пространство межмуниципального взаимодействия: оценка потенциала и его реализации

АННОТАЦИЯ
Актуальность. Межмуниципальное взаимодействие представляет собой действенный инструмент компенсации имеющихся у муниципальных образований дефицитов, актуальность использования которого возрастает в сегодняшних нестабильных социально-экономических условиях. Это определяет значимость верного выбора муниципальными образова-

КЛЮЧЕВЫЕ СЛОВА
взаимозависимость муниципальных образований, межмуниципальное взаимодействие, муниципалитет, размещение,

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ниями партнеров для такого сотрудничества, заставляя задуматься о том, насколько важной предпосылкой взаимодействия является теснота связей между муниципалитетами.
Цель исследования. Определить, насколько увязаны между собой пространственные особенности взаимозависимости муниципальных образований и их взаимодействия друг с другом**.**
Данные и методы. Работа базируется на официальных статистических данных, предоставленных Федеральной службой государственной статистики, информации, изложенной в инвестиционных паспортах и стратегиях социально-экономического развития муниципальных образований. В основе методического инструментария исследования лежат методы пространственной корреляции и картографического анализа, а также общие методы познания, включающие в том числе методы анализа и синтеза.
Результаты. Показано, что пространство межмуниципальных взаимосвязей Свердловской области отличается значительной неоднородностью: ярко выраженным полюсом их концентрации является административный центр субъекта РФ с окружающими его муниципалитетами, а наименьшей связанностью отличаются северные и восточные территории региона. Выявлено, что разные части пространства области также отличаются друг от друга степенью вовлеченности локализованных в них муниципальных образований в реализацию совместных проектов. Наиболее активно осуществляют такие проекты члены Екатеринбургской городской агломерации, тогда как взаимодействие между муниципалитетами, локализованными на юго-западе региона, является менее интенсивным. Север и восток области в еще меньшей степени вовлечен в процессы формирования партнерских отношений с прочими территориями.
Выводы. Полученные результаты подтверждают наличие тесной связи между параметрами взаимозависимости муниципальных образований и масштабами их взаимодействия. На перспективы сотрудничества влияет не только фактор территориальной и социально-экономической близости муниципалитетов друг к другу, но и дополнительные движущие силы (например, проводимая в стране или регионе политика), при этом нехватка ресурсов у потенциальных союзников не выступает значимой предпосылкой их объединения.

пространственный анализ, стратегия развития, межмуниципальный проект, региональная политика, управление пространственными преобразованиями

БЛАГОДАРНОСТИ
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城市间互动空间：潜力评估及其实现

摘要
现实性：市镇间合作是弥补市镇赤字的有效工具，在当今不稳定的社会经济条件下，使用这种工具的相关性越来越大。这就决定了市政当局为这种合作正确选择伙伴的重要性。这迫使人们思考市政当局之间关系的密切程度是互动的重要先决条件。
研究目标：确定各城市之间相互依存的空间特征及其相互影响的关联程度。
数据与方法：这项工作以联邦国家统计局提供的官方统计数据、投资护照中包含的信息以及各市的社会经济发展战略为基础。研究的方法工具基于空间关联和制图分析方法，以及一般认知方法，包括分析和综合方法。
研究结果：研究表明，斯维尔德洛夫州的市镇间联系空间具有显著的异质性：其最集中的区域是俄罗斯联邦的行政中心及其周边市镇，而该州北部和东部地区的联系则最少。据调查，该地区的不同部分在参与实施联合项目的程度上也各不相同。叶卡捷琳堡城市群最积极参与这些项目，而该州西南部的城市之间的互动就不那么紧密。该州北部和东部地区与其它地区建立合作关系更少。
结论：研究结果证实，各城市之间相**互依存的参数与其合作**规模之间存

关键词
市镇相互依存、市镇间互动、市镇、位置、空间分析、发展战略、市镇间项目、区域政策、空间转型管理

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在密切关系。合作前景不仅受到城市之间的地域和社会经济距离因素的影响，还受到其他驱动力（例如，国家或地区推行的政策）的影响，而潜在盟友缺乏资源并不是它们结盟的重**要先决条件**。

Introduction

Municipalities frequently encounter a diverse array of developmental challenges, and their ability to respond effectively is often constrained by insufficient resources and capacity limitations. In today's unstable socio-economic climate, the lack of funds to tackle all emerging issues is becoming an even bigger problem, which pushes municipal leaders to find new ways to address these shortages. One solution is for municipalities to collaborate and combine their efforts and resources to solve similar problems and achieve common development goals.

Inter-municipal cooperation is becoming more common in many countries (Hulst & van Montfort, 2012; Silva et al., 2018). It has proven to be effective in securing local government funding and improving the quality of decision-making, while also speeding up the realization of plans. However, cooperation between municipalities doesn't always deliver the expected results. In some cases, the effort spent on joint projects outweighs the benefits they bring (Prosenewicz & Lippi, 2012), and inter-municipal cooperation does not always lead to sustainable regional development. There are several factors that influence the success of such cooperation: the legal and regulatory framework for establishing partnerships, the policies implemented in the region (Gresova & Fuka, 2018), the competencies of local authorities, the level of trust in society (Kwiatkowski et al., 2024), the sector in which cooperation takes place (Muraoka & Avellaneda, 2021), and other factors. Many of these factors are closely tied to the characteristics of the municipalities involved in the cooperation. Undoubtedly, the specifics of cooperation largely depend on who is involved, which raises some important questions: What is the best way to identify suitable partners for cooperation? Is inter-municipal cooperation most effective when municipalities have close ties with one another? How should cooperation be organized between municipalities of different types? And so on.

This study explores key aspects of inter-municipal cooperation, particularly how the physical locations of municipalities and their interdependence influence their interactions. To achieve this, the study first assesses the potential for resource consolidation and collaborative efforts among the municipalities under analysis, considering the geographical differences between them. It then examines the extent and structure of their interactions, analyzing how these connections are organized in the region. Finally, the findings from these analyses are compared in order to identify relationships between geographical proximity, resource sharing, and interaction dynamics, offering insights into the factors shaping inter-municipal cooperation.

Theoretical Framework

A significant body of contemporary research is devoted to the processes that accompany the relationships between municipalities. While some studies deal with the topic of competition and rivalry between municipalities, others are particularly focused on the issues of their cooperation.

The discussions often revolve around various aspects of inter-municipal cooperation. However, most authors seek to identify the factors that drive municipalities to consolidate resources and efforts, as well as to assess the consequences of such consolidation and the resulting effects.

For example, Struck and Bakos (2021) demonstrate that cooperation between municipalities in waste management allows them to significantly reduce costs for providing this service. The existence of economic benefits from municipal cooperation is also noted in works by Giacomini et al. (2018), Silvestre et al. (2019), and several other studies. Some authors, however, have a more nuanced view of the possible outcomes of inter-municipal cooperation, noting that the emergence of positive effects, as well as their scale, depends on various factors, such as the nature of the task that the consolidation of municipal resources aims to solve (Muraoka & Avellaneda, 2021) and the characteristics of the partners involved (Baba & Asami, 2019). Some studies try to assess the results of inter-municipal cooperation beyond just measuring economic benefits, focusing on the changes in residents' satisfaction with the services provided through cooperation (Holum & Jakobsen, 2016), the state of the environment (Kwadwo & Skripka, 2022), the level of municipal employees' compe-

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tencies (Silvestre et al., 2020), the state of democracy (Eythorsson, 2019), the extent of social segregation (Schone, 2022), and other factors.

In their analysis of the factors that influence both the interest of municipalities in cooperation and the effectiveness of such cooperation, researchers mainly focus on the institutional foundations of organizing collaboration (dos Santos et al., 2022; Jacobsen & Kiland, 2017; Soukopova & Vacekova, 2016), the financial resources available to municipalities (Bel & Warner, 2015; Bocchino & Padovani, 2021; Gendzwill et al., 2019; Warner et al., 2020), the characteristics of potential partners' locations (Gerstlberger et al., 2023; Kolsut, 2016), and the proximity of their development parameters (Bischoff & Wolfschutz, 2020; Melichova & Varecha, 2020; Steiner, 2003). It should be noted, however that not all studies confirm the significance of the impact of these factors on the development of inter-municipal relations. For example, Nelles (2011) uses the case of municipalities in the Detroit-Windsor cross-border agglomeration to show that despite shared characteristics—such as economic specialization, similar cultural and social challenges linked to economic decline, and well-established migration flows, the level of inter-municipal cooperation in the region remains very low. This suggests the need for a more comprehensive approach to studying the nature of the relationships that unite municipalities, as well as the complexity involved in identifying the most effective strategies for forming inter-municipal partnerships.

Still, several researchers have made attempts to resolve this issue. For instance, Voroshilov (2021) proposes a model for determining the feasibility of inter-municipal cooperation that is suitable for application in Russian contexts. This model also aids in identifying the most appropriate form for organizing such cooperation. The purpose of this model is to analyze the potential for consolidation among municipalities to achieve common goals. It examines criteria such as the available resources of the municipalities, the strength of their connections, and the degree of differentiation in their development. Other scholars have also proposed different approaches to assessing the potential for inter-municipal cooperation. For instance, Barabash and Leonov (2012) identify a direct correlation between this potential and the proximity of municipalities to each other in terms of their location, population density, and levels of socio-economic development. The methodology presented by Arumova (2013) is based on comparing the cost of implementing municipal powers per capita in an autonomous mode versus in a cooperative setting. Some experts (Kozlova & Makarova, 2018), when evaluating the prospects of municipal cooperation, prefer not to analyze quantitative characteristics but to focus on the strategic intentions outlined in municipalities' planning documents regarding joint projects with other territorial units.

It should be noted that when evaluating the scope of interaction already taking place among municipalities (either currently or retrospectively), researchers often actively use content analysis, examining specific cases in detail (de Freitas et al., 2020; de Morais & de Freitas, 2023; Khuzhakhmetova, 2020). They also compare the institutional frameworks for inter-territorial relations that have developed in different regions or countries (Bel et al., 2022; Klimovsky et al., 2014; Traore, 2023). Another highly valued tool frequently used in such assessments is surveys conducted among representatives of municipal management bodies (Bergholz & Bischoff, 2018; Holen-Rabbersvik et al., 2018; Rus et al., 2018). The reason for this is that generalized statistical data available to the public about inter-municipal cooperation in a region or country are often insufficient for making comprehensive conclusions about the quality of these relationships. Typically, such data only describe the number of agreements signed or associations formed. In addition to supplementing this information with content analysis results or survey data, financial and accounting reports from inter-municipal associations can also be useful (Sedmihradska, 2018).

It can be concluded that significant experience has been accumulated in assessing both the parameters of interdependence among municipalities and the scope of their interaction. However, these studies typically focus on only one of these issues. Therefore, this study seeks to expand the scope of the issues addressed by focusing on specific aspects of territorial cooperation, particularly regarding the opportunities and limitations in utilizing the available potential for such collaboration.

Method and Data

The area covered by this study consists of municipalities of Sverdlovsk region, one of Russia's

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old industrial regions in the Urals. Although overall there are 94 such entities, only 73 of them—68 urban districts and 5 municipal districts—were selected for this analysis (the remaining 5 urban and 16 rural settlements are part of the municipal districts). It is worth noting that there is already a considerable body of research devoted to various aspects of spatial organization in Sverdlovsk region: agglomeration processes (Animitsa & Vlasova, 2020; Izhguzina, 2017), spatial policy implementation (Antipin et al., 2023; Turgel et al., 2020), and the development characteristics of specific territorial units and their complexes (Dvoryadkina et al., 2022; Pryadein & Kazakova, 2023). Therefore, I intend to complement the available research evidence with an analysis of the region's potential for inter-municipal cooperation.

To assess the degree of dependency among municipalities, it makes sense to examine their access to financial resources (both budgetary and non-budgetary) and the number of residents. Population and available resources for development reflect a territory's potential for growth and serve as key indicators of ongoing transformations within its boundaries. These metrics can be used to identify systems that are socially and economically similar.

The analytical tools used in the study are based on the method of spatial correlation, involving the calculation of Moran's indices (Moran, 1948). These indices provide a quantitative assessment of the spatial relationships between territorial units similar in the parameters under consideration. A detailed description of the calculation algorithm and data interpretation can be found in my previous works (Lavrikova & Suvorova, 2019; Suvorova, 2021) as well as in publications by other authors (Naumov, 2019; Pavlov & Koroleva, 2014). A key part of the analysis is creating a Moran's scatter plot (Table 1), which helps identify standardized values of the analyzed indicator (z_i) and spatially weighted centered values (w_{zi}), which means that municipalities can be classified depending on their role in the regional distribution of the evaluated resource (e.g., population or investment funds).

For a more detailed grouping of territories, the local Moran's index (1) should be considered. Municipalities with high values of this index ($|I_{Li}| > |I_L|$) have the strongest connections with other territorial units.

$$I_{Li} = z_i \sum w_{ij} z_j, \quad (1)$$

where I_{Li} is the local Moran's index for the i-th municipality, w_{ij} is the standardized distance between the i-th and j-th municipalities, z_i and z_j are the standardized values of the analyzed indicator for the i-th and j-th municipalities.

Table 1

Moran's scatter plot

LH (Low – High) z_i *negative,* w_{zi} *positive* Territories with relatively low values in the given indicator, whose neighbors have relatively high values	**HH (High – High)** z_i *positive,* w_{zi} *positive* Territories with relatively high values in the given indicator, whose neighbors also have relatively high values
LL (Low – Low) z_i *negative,* w_{zi} *positive* Territories with relatively low values in the given indicator, whose neighbors also have relatively low values	**HL (High – Low)** z_i *positive,* w_{zi} *negative* Territories with relatively high values in the given indicator, whose neighbors have relatively low values

Source: (Moran, 1948)

This study analyzes data from 2018 to 2023, using average values in the calculations. The period begins in 2018, as this was the year when municipal socio-economic development strategies were approved. The development of these strategies followed a unified approach defined by regional authorities and outlined in a set of methodological recommendations[1]. A key component of this approach is a section in each document that defines prospects for cooperation with other municipalities and describes planned joint projects. In addition to declared and implemented inter-municipal projects—whose analysis helps identify areas of interaction between territorial units and assess each municipality's involvement in cooperation—active agreements, associations, and alliances are also of interest. The presence of these partnership structures in the region indicates the consolidation of resources, especially informational ones, among municipalities.

An important element of the methodology is the use of cartographic representations that visualize the location specifics of different municipalities and the nature of their interconnections, as well as clearly demonstrate the differences in the parameters of interdependence and cooperation between municipalities.

[1] Resolution of the Government of Sverdlovsk Region No. 208-PP dated March 30, 2017, «On Methodological Recommendations for the Development (Updating) of Socio-Economic Development Strategies for Municipalities Located in Sverdlovsk Region.»

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Results

The population distribution in Sverdlovsk region is uneven as there are clear contrasts between densely populated areas and those with sparse populations (Figure 1). The «population size» indicator shows a negative spatial correlation (the global Moran index is –0.017), which can be explained by the presence of the million-plus city of Ekaterinburg, which accounts for 37.4% of the region's population. Ekaterinburg is also the center of an agglomeration, which holds more than half of the region's population. Along with the Ekaterinburg agglomeration, two other agglomerations are traditionally identified in the region's settlement system: the Gornozavodskaya agglomeration (centered in the city of Nizhny Tagil) and the Serov agglomeration (which includes several settlements in the northern part of the region). However, while the Nizhny Tagil agglomeration can be classified as an emerging agglomeration,

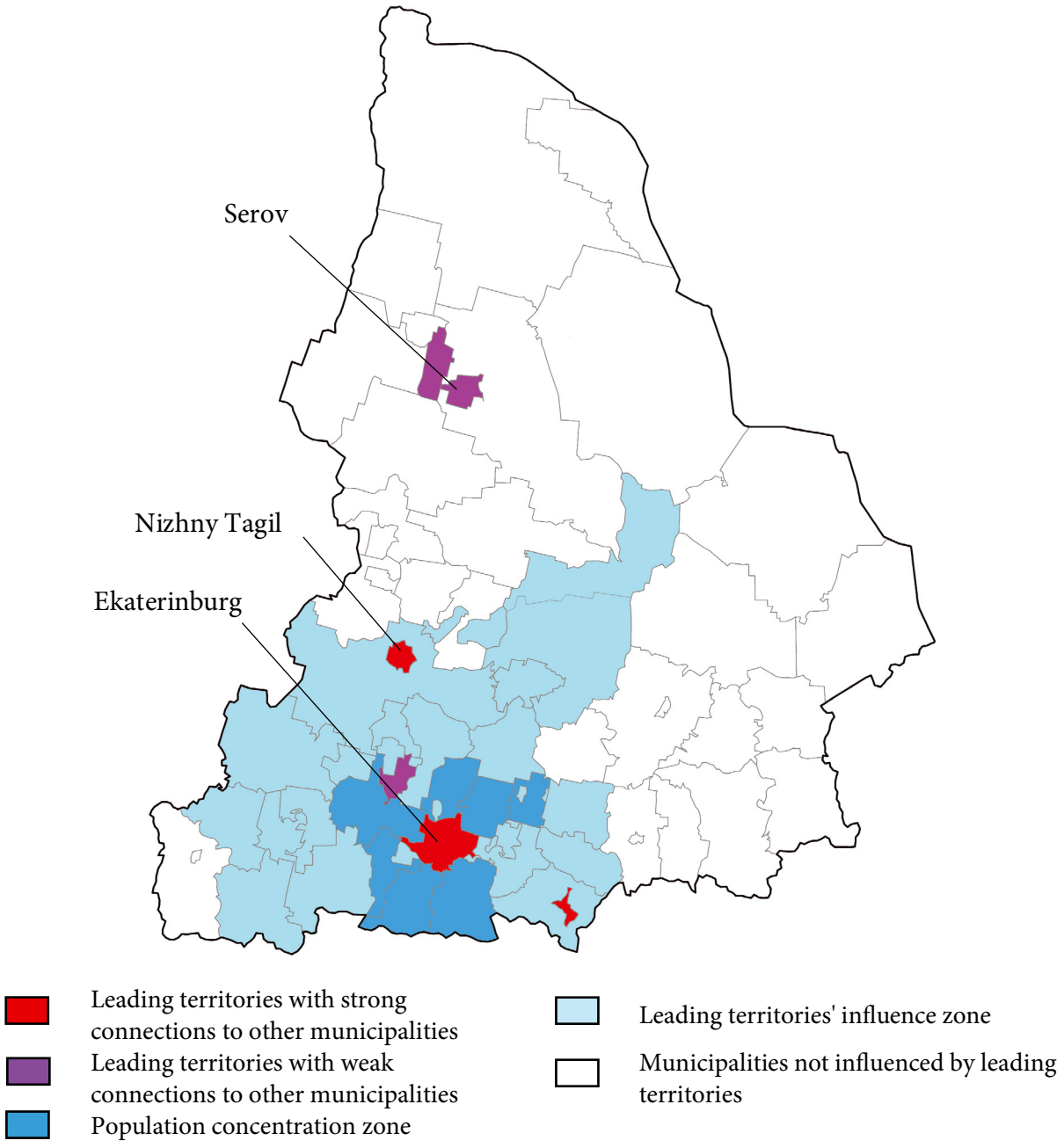

Figure 1. *Territorial correlation of municipalities in Sverdlovsk region (parameter: population size)*

Source: the author's calculations are based on statistical data (Rosstat), indices: Database of municipal indicators. Retrieved from: https://rosstat.gov.ru/storage/mediabank/munst.htm (Accessed: 12.08.2024)

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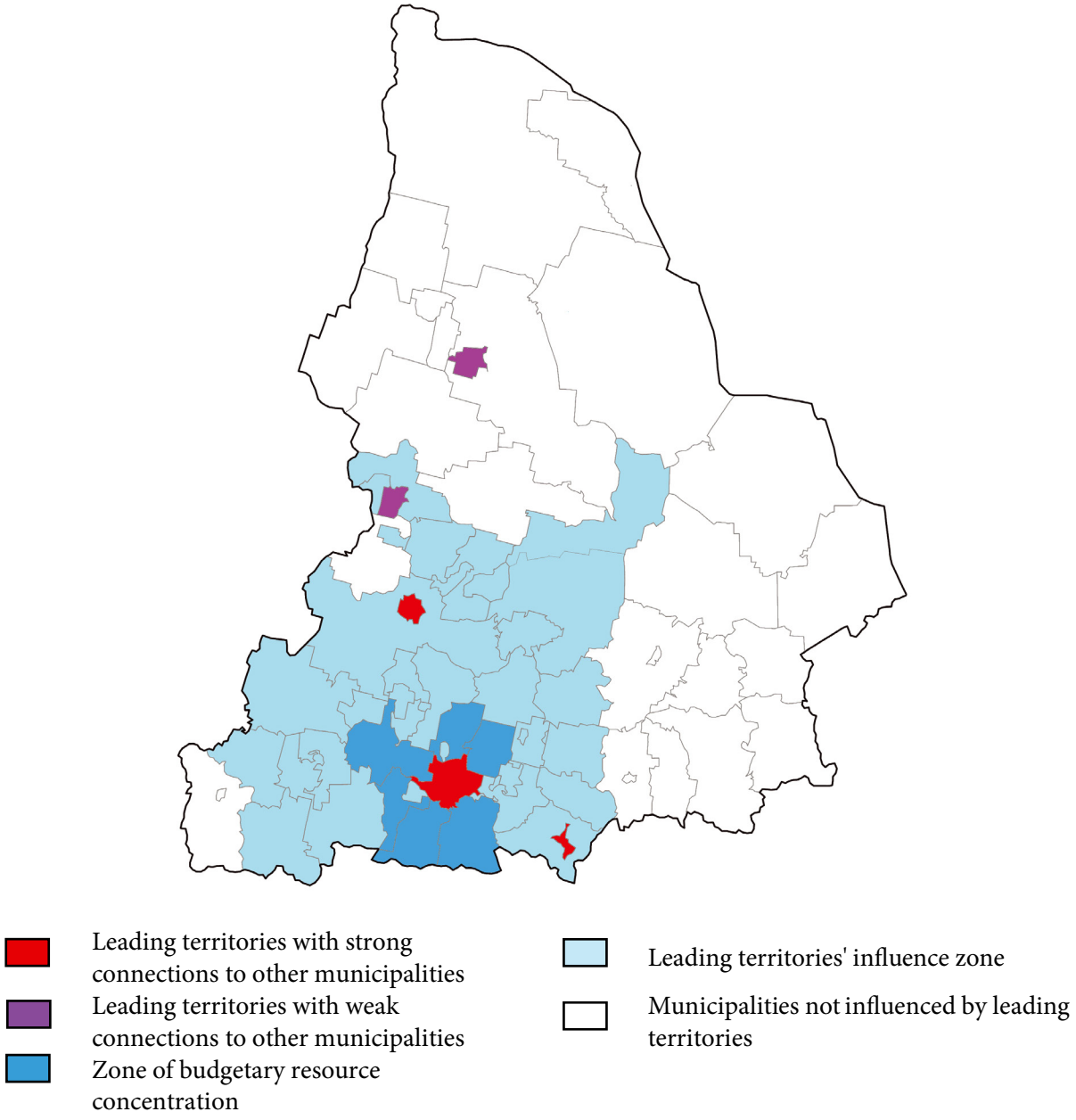

Figure 2. *Territorial correlation of municipalities in Sverdlovsk region (parameter: actual local budget revenues)*

Source: the author's calculations are based on statistical data (Rosstat), indices: Database of municipal indicators. Retrieved from: https://rosstat.gov.ru/storage/mediabank/munst.htm (Accessed: 12.08.2024); Sverdlovsk region's investment portal, indices: Investment climate of municipalities. Retrieved from: https://invest-in-ural.ru/invest-mo/ (Accessed: 14.08.2024)

the Serov agglomeration currently lacks the potential to generate an agglomeration effect (this can be seen from the results of calculations of territorial correlation between the municipalities included in it).

Thus, population centers are concentrated in the southwestern part of the region, where the largest settlements are located in a relatively small area and are closely connected to each other. Municipalities in the northern and eastern parts generally have low population density, which may indicate their relatively low potential for interaction both with each other and with leading territories (due to their remoteness).

The distribution of financial resources accumulated in local budgets generally follows the logic of the region's settlement system (Figure 2). Once again, the majority of resources are concen-

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trated within the boundaries of the Ekaterinburg urban agglomeration, whose core and peripheral areas significantly differ from the surrounding territories. The northern and eastern areas of the region are different from the administrative center and the nearby areas: the budgetary revenues of municipalities there are relatively low. Most of these municipalities are large in terms of area, with settlements located far apart from each other. This feature may require municipal leaders to work together to address challenges, like providing infrastructure access, due to limited resources.

Investment resources in the given period were also primarily concentrated in the southwestern part of the region (Figure 3). However, the distribution system of these resources has its peculiarities: some of its extremes are located in the central part, while most municipalities in the Ekaterinburg agglomeration do not fall within the concentration zone of the resources in question. This can be explained by the fact that the investment attractiveness of territories is linked not so much to the scale

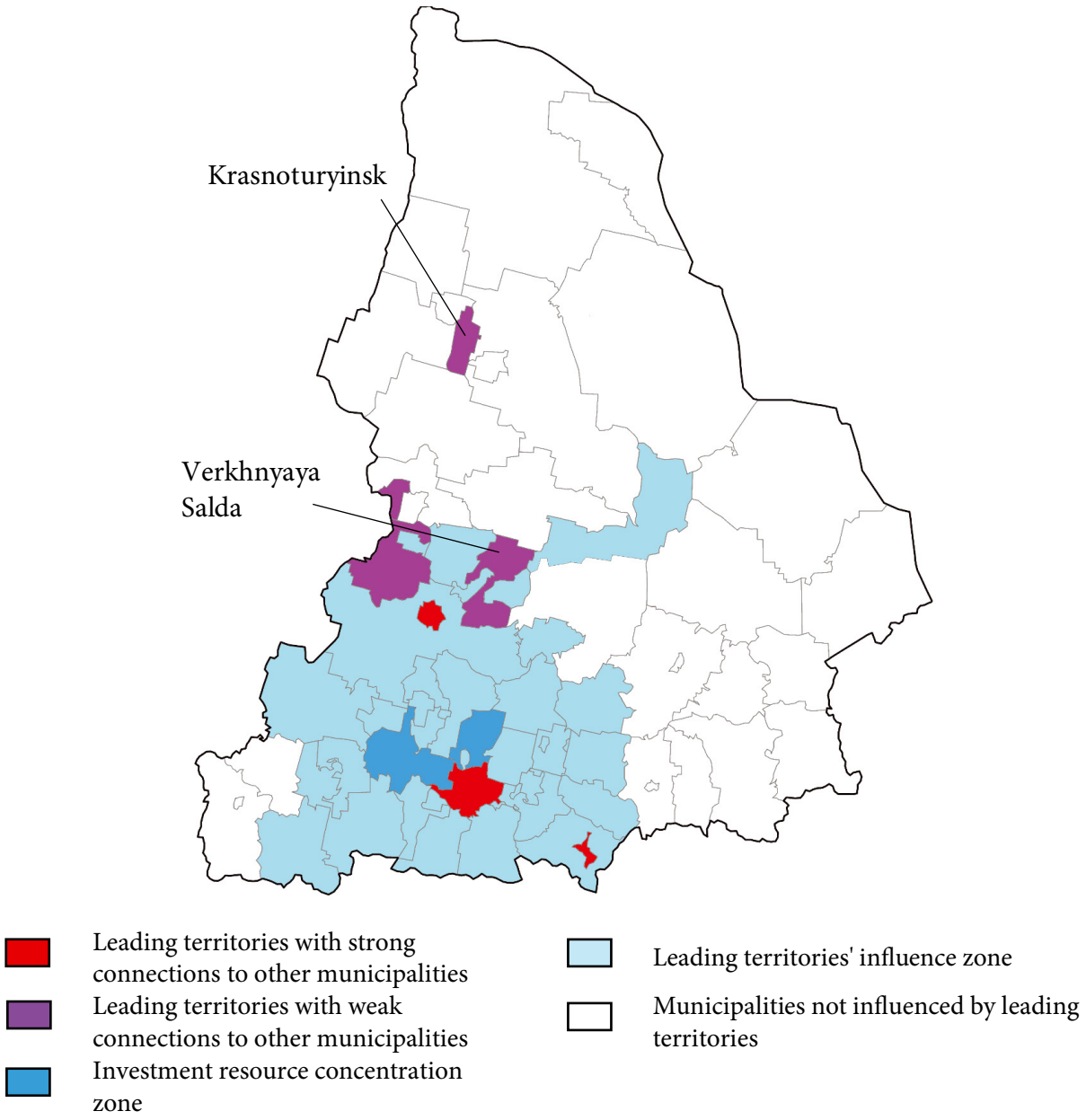

Figure 3. *Territorial correlation of municipalities in Sverdlovsk region (parameter: volume of investments in fixed assets)*

Source: the author's calculations are based on statistical data (Rosstat), indices: Database of municipal indicators. Retrieved from: https://rosstat.gov.ru/storage/mediabank/munst.htm (Accessed: 12.08.2024)

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of their socio-economic systems, but to the availability of promising projects or sites for development, as well as specific support measures for investors that can help drive the growth of these systems. For example, investor interest in municipalities in the northern and central parts (such as Krasnoturyinsk and Verkhnyaya Salda) can be explained by the special preferential regime available for residents operating in these areas.

It should be concluded that the key position in the system of inter-municipal relations in Sverdlovsk region belongs to its administrative center – Ekaterinburg. It accumulates resources of various types, forming a zone of concentration around itself. The surrounding territorial units have strong potential for interaction, not only with Ekaterinburg but also among themselves. Other relatively large municipalities form smaller-scale complexes with their neighbors. The level of connectivity of the municipalities located in the region's north and east is low. However, as mentioned earlier, the typical resource shortages in many of these areas could motivate them to join forces to address shared challenges.

The socio-economic development strategies of nearly all municipalities in Sverdlovsk region emphasize the importance of building stable inter-municipal ties and implementing joint initiatives. In 35 out of 73 reviewed documents, this focus appears to be driven by the regional strategic planning approach, which requires municipalities to include prospects for inter-municipal partnerships. These strategies, while acknowledging the importance of cooperation, do not specify particular projects or identify key partners. In contrast, the strategies of other municipalities mention specific projects with varying levels of detail, demonstrating a wide range of approaches (Table 2).

The largest group of proposed projects is related to the creation (or transformation) of facilities in municipal areas that could eventually serve residents from other territorial units. For example, the Strategy of Berezovsky presents a project to renovate the «Zarnitsa» health resort, turning it into a multifunctional year-round complex, providing services that may interest residents of other municipalities. Such projects, however, do not necessarily require cooperation between municipalities (either during their implementation or in the utilization of their benefits), so classifying them as inter-municipal projects seems inappropriate.

Table 2

Typology of interterritorial projects included in the socio-economic development strategies of municipalities in Sverdlovsk region

Project implementation area	Number of projects	Number of municipalities involved in project implementation
Management of industrial and consumer waste	10	21
Road system	13	29
Transport and logistics system	5	6
Utilities	15	21
Tourism	6	13
Social sphere	11	31
Creation/reconstruction of facilities of interest to residents of other municipalities	17	33

Some of the projects outlined in municipal strategies (for example, those related to the road system or waste management) are based on regional territorial planning documents, aligning with activities defined by higher-level authorities. These plans typically involve creating numerous inter-municipal connections that link most of the region's territorial units. For instance, the Territorial Scheme for Waste Management in Sverdlovsk Region is establishing a system of inter-municipal waste management centers that serve neighboring municipalities (Figure 4).

Projects of other types involve a small number of municipalities, and the networks of connections between them change significantly as you move from one group of projects to another (Figure 5).

A significant number of projects involve more than two municipalities (typically, as resource consumers from the partnering municipality). These projects are most commonly aimed to develop public infrastructure (for example, a project using water bodies in Revda for supplying water to other municipalities) or focus on the social sector (for example, building an inter-municipal healthcare center in Revda, which also serves the populations of Degtyarsk, Biserte, and the Lower Serginsky Municipal District). A distinctive feature of some projects, particularly in the tourism sector, is the cooperation between municipalities located at a considerable distance from each other (often linked by a common historical event or

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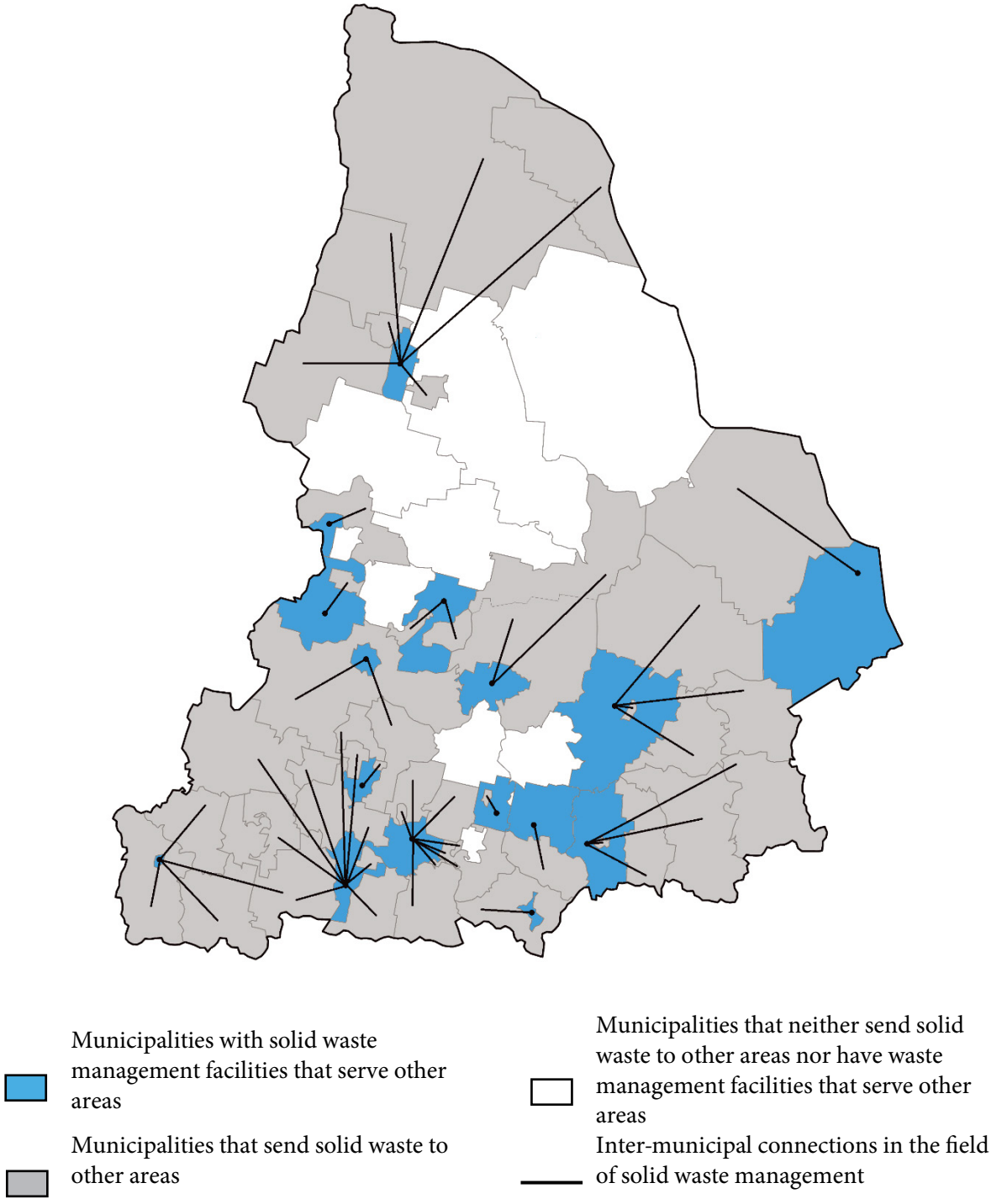

Figure 4. *Inter-municipal connections in the field of industrial and consumer waste management*

Source: Territorial scheme for handling production and consumption waste in Sverdlovsk region. Retrieved from: https://energy.midural.ru/tko/territorialnaya-shema-obrashheniya-s-othodami-proizvodstva-i-potrebleniya-na-territorii-sverdlovskoj-oblasti/ (Accessed: 22.08.2024)

notable figure). However, the vast majority of inter-municipal collaborations are based on the interaction of neighboring territories.

Also notable is the proximity of municipalities involved in inter-municipal projects of similar scale (Figure 5). The most active participants are municipalities in the Ekaterinburg urban agglomeration (and their immediate neighbors). Munic-

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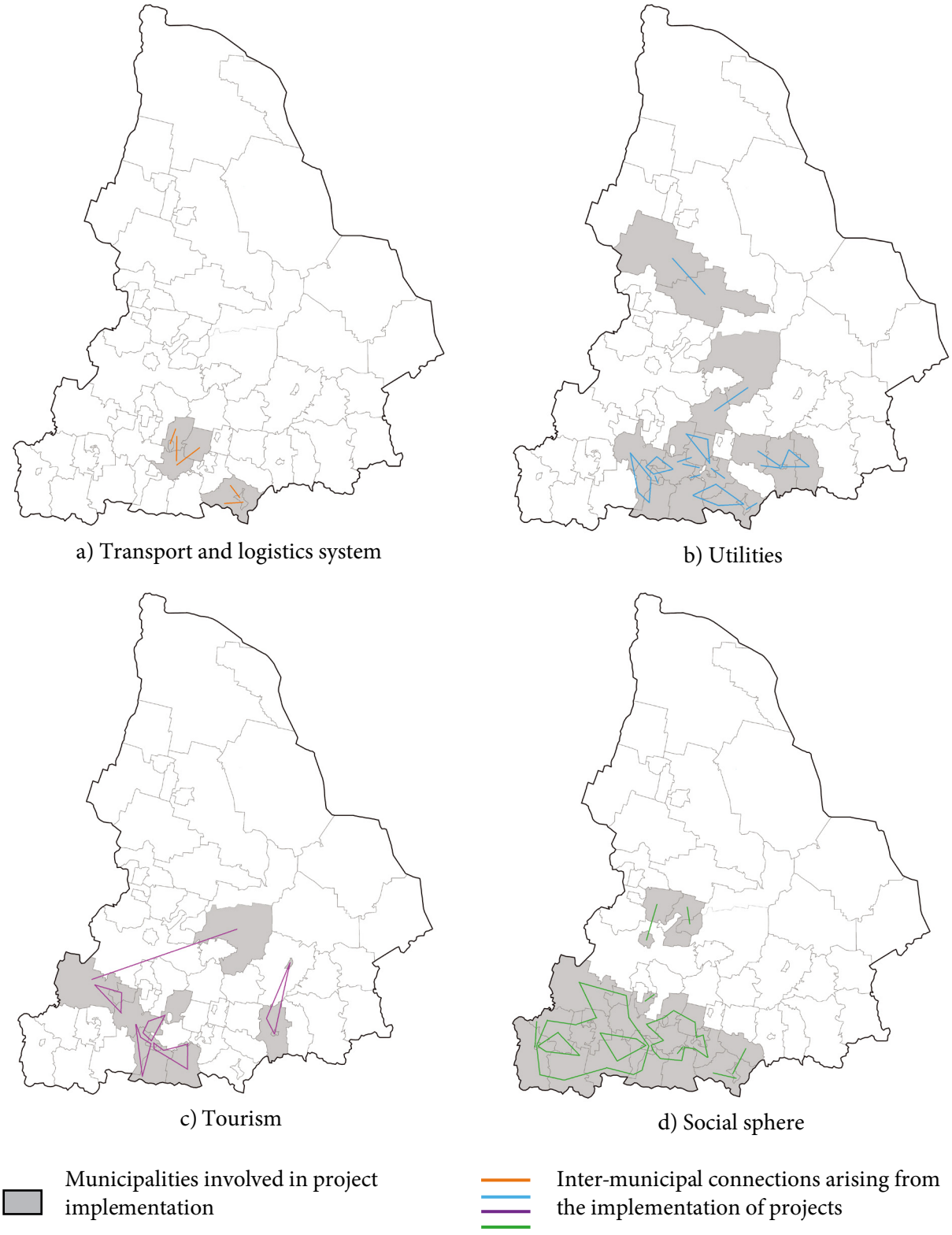

Figure 5. *Localization of municipalities participating in joint projects of various types*

Source: Socio-economic development strategies of the municipalities of Sverdlovsk Region (available on the official websites of these municipalities).

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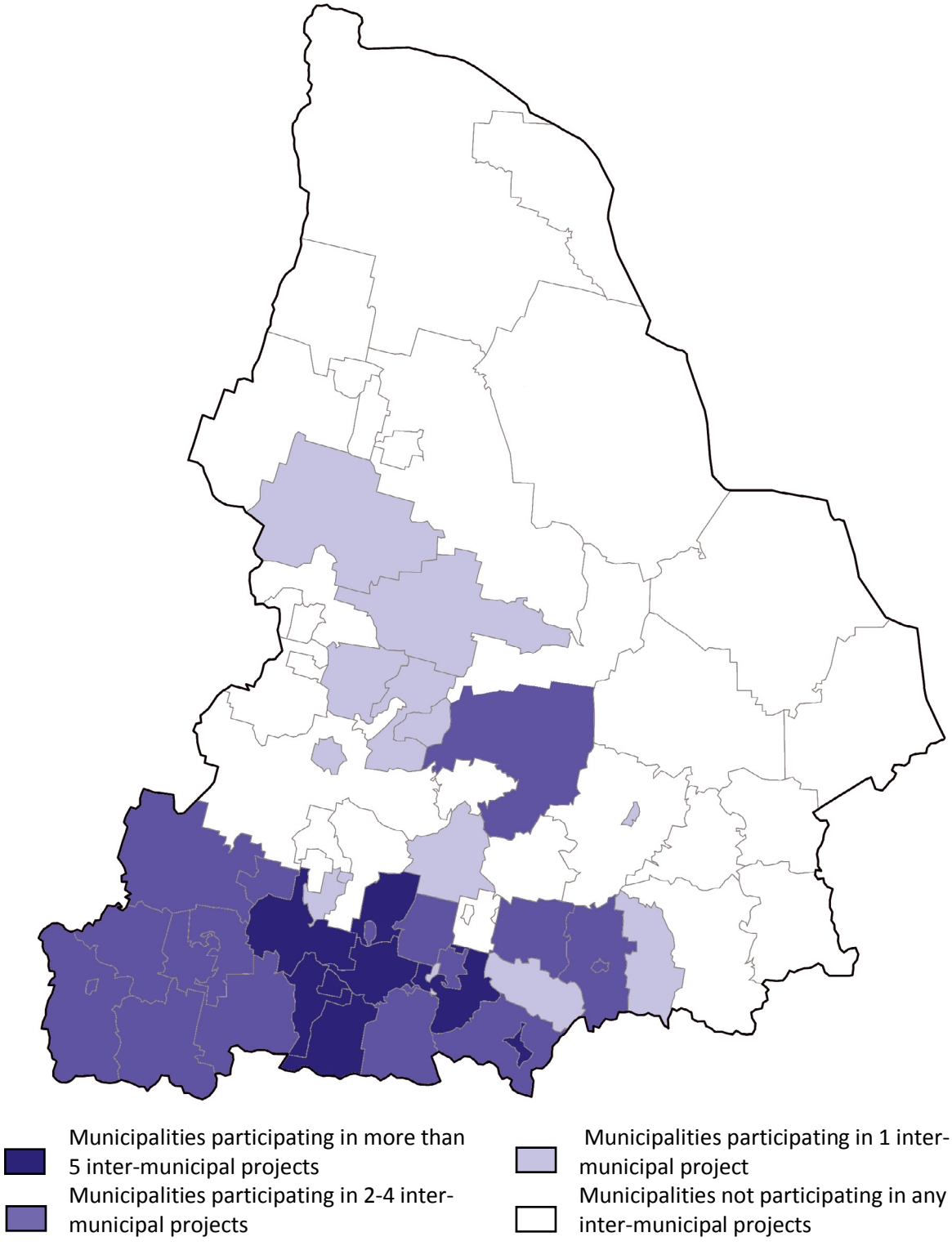

Figure 6. *Localization of municipalities based on the number of inter-municipal projects for developing transport, infrastructure, tourism, and the social sector*

Source: Socio-economic development strategies of the municipalities in Sverdlovsk Region (available on the official websites of these municipalities).

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ipalities in the southwestern part are also significantly involved in inter-municipal cooperation. In contrast, the north and east of the region appear unwilling to unite with other territories to solve common problems.

Along with implementing joint projects, the municipalities of Sverdlovsk Region participate in various associations and unions. The level of involvement of territorial units in these structures is significant: every municipality in the region is a member of at least one of them. This trend is largely determined by the national regulatory framework for local self-government: according to the law[2], each region must have a council of municipalities to facilitate interaction between the authorities of the territories it includes.

The region's municipalities are also members of several associative organizations, the creation of which is not legally required. A prominent example of a local union is the Ekaterinburg Urban Agglomeration, which comprises 14 members who identify as part of a unified agglomeration system. Some municipalities are also part of larger systems. For instance, Ekaterinburg and Nizhny Tagil are members of the Union of Russian Cities, which serves as a center of expertise for local government bodies; Kirovgrad, Nizhnyaya Salda, and Zarechny are part of the Association of Small and Medium Cities of Russia, and so on.

Conclusions

The analysis confirms a correlation between the interdependence of municipalities and the scale of their interactions: the structure of inter-municipal connections and cooperation is organized in a similar way. Municipalities located in resource-concentrated areas tend to cooperate most closely with each other and with leading territories. In contrast, municipalities that lag behind in terms of population and financial resources, and are distant from major urban centers, show lower levels of involvement in partnerships. This highlights the importance of factors like territorial proximity and similar development parameters for successful inter-municipal cooperation. At the same time, it challenges the assumption that a resource deficit is a key factor driving municipalities to unite.

However, this study shows that interaction between territories with relatively low potential is still possible. Such collaboration can be driven by additional factors. For example, federal or regional policies could play a key role by redistributing responsibilities among municipalities or encouraging the exchange of information, solutions, and best practices across regions. A crucial factor in this process is setting clear and appropriate goals for the «top-down» request to unite municipalities. Attempts to create intermunicipal associations without a solid foundation often lead to the emergence of formal structures with little genuine interaction among participants, preventing the effective resolution of existing problems or significant challenges. This perspective has led some authors (Kolesnikov, 2021) to view skeptically the high levels of municipal involvement that are prevalent in associative unions formed solely on a mandatory basis due to regional affiliation (Sverdlosvk region is no exception in this regard). If cooperation between territories allows all stakeholders to solve a specific problem and its potential benefits are clear to the participants, the potential for interaction is significant (even in the absence of close ties between municipalities). If external driving forces complement existing interterritorial connections, the effect of the partnerships being formed can be expected to be even more noticeable.

The research highlights the importance of careful participant selection in inter-municipal interactions and emphasizes the need to improve methods for assessing the interdependence between municipalities. A promising direction for further research is the development of methodological tools to measure the degree of connectivity between territories, using a broad range of indicators—such as those related to the social sector, scientific and technological development, and industry-specific factors. Additionally, research on how to effectively leverage existing cooperation potential between territories is highly relevant. These findings can be practically applied, particularly in identifying the most promising inter-municipal partnerships, making them valuable for regional authorities at all levels responsible for regional policy implementation.

[2] Federal Law of the Russian Federation No. 131-FZ of October 6, 2003, «On the General Principles of Local Self-Government Organization in the Russian Federation»

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Environmental risks and sustainable development of russian regions in times of crises

ABSTRACT
Relevance. Russia is currently facing sanctions, which have had significant economic and social consequences. These crises have revealed vulnerabilities in the socio-economic system, highlighting the importance of studying them to better address current challenges and mitigate future risks.
Objective. The study aims to identify the vulnerabilities in particular aspects of sustainable development across Russia's regions during the crises of the past 15 years.
Data and methods. The study draws on data from the Federal Statistical Service (Rosstat) to calculate a sustainable development index for regions, which tracks the impact of crises on their economic, social, and environmental sustainability. The index is constructed using a classical method, comprising three averaged sub-indices, each representing one of the three components of sustainable development. A higher index value indicates greater sustainability, with the impact of crises varying across regions.
Results. During the 2014 crisis, regions specializing in export-oriented industries or those with a significant share of foreign capital in their economies were hit the hardest. Socially, the most vulnerable regions were those along the Chinese border in the Far East, which were impacted by trade restrictions. The 2020 pandemic had economic effects on nearly all regions, with cities of over a million people and their agglomerations suffering the most due to the abrupt suspension of the tertiary sector. The social sphere responds most quickly to crises, while the environmental component is more inert but shows a negative trend despite the crises.
Conclusions. For regions with underdeveloped and monocentric economies, support measures should focus on diversifying industries, particularly those aimed at mass consumption. In coal-mining regions, it's important to develop service sectors related to the industry during stable periods. For the Far Eastern regions, the main support measure is to stimulate industries geared towards meeting Chinese demand.

KEYWORDS
environmental risks, sustainable development, factors of socio-economic development, regions of Russia, integral indices, crises

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Экологические риски и устойчивое развитие регионов России в условиях кризисов

АННОТАЦИЯ
Актуальность. В настоящее время Россия подвергается санкционному воздействию, что влечёт за собой экономические и социальные последствия. За последние 15 лет страна проходила через несколько кризисных этапов и уже располагает опытом для их преодоления. Любой кризис демонстрирует уязвимости действующих социально-экономических си-

КЛЮЧЕВЫЕ СЛОВА
экологические риски, устойчивое развитие, факторы социально-экономического развития, регионы России, интегральные индексы, кризисы

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стем, а их изучение позволяет определить, каким образом можно облегчить преодоление нынешних и будущих кризисных явлений.
Цель исследования заключается в определении уязвимости составляющих устойчивого развития в разрезе регионов России в ходе кризисов последних 15 лет.
Данные и методы. На основе данных Росстата вторами рассчитан индекс устойчивого развития регионов, позволяющий отследить влияние кризисов на экономическую, социальную и экологическую устойчивость регионов. В основе – классический метод составления индекса, состоящего из трёх осреднённых субиндексов, характеризующих одну из трёх составляющих устойчивого развития. Более высокое значение индекса соответствует более высокой устойчивости, но влияние кризисов неодинаково.
Результаты. В ходе кризиса 2014 года больше пострадали регионы с отраслями специализации, ориентированными на экспорт, либо те, где значимую роль в экономике играли предприятия с высокой долей иностранного капитала. В социальном плане более уязвимыми оказались приграничные с Китаем регионы Дальнего Востока, вследствие торговых ограничений. В результате пандемии 2020 года в экономическом отношении пострадали почти все регионы, особенно сильно – города-миллионники и их агломерации, из-за резкой приостановки работы третичного сектора. Наиболее быстро реагирует на кризисы социальная сфера, экологическая же составляющая инерционна, но имеет негативный тренд, несмотря на кризисы.
Выводы. В качестве мер поддержки для регионов с отсталой и монопрофильной экономикой – диверсификация промышленности за счёт отраслей, ориентированных на массовое потребление. Для регионов со специализацией на угледобыче необходимо по развитие отраслей, связанных с обслуживанием данной отрасли в период, когда кризисы отсутствуют. Для регионов Дальнего Востока основным вариантом поддержки является развитие отраслей, ориентированных на китайский спрос.

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危机条件下俄罗斯各地区的环境风险与可持续发展

摘要
现实性：俄罗斯目前正受到的制裁造成了经济和社会后果。在过去的15年中，俄罗斯经历了数次危机，并积累了克服危机的经验。任何危机都可使当前社会经济体系的脆弱性显现，对其进行研究可以确定如何渡过当前和未来的危机现象。
研究目**标：**目的是确定俄罗斯各地区在过去15年危机期间可持续发展各组成部分的脆弱性。
数据与方法：根据俄罗斯统计局的数据，作者计算出了地区可持续发展指数，使我们能够跟踪危机对地区经济、社会和环境可持续性的影响。该指数基于经典的指数编制方法，由三个平均的子指数组成，分别表征可持续发展的三个组成部分之一。指数值越高，可持续性越强，但危机的影响并不等同。
研究**结果：**在2014年危机期间，出口导向型产业或外资企业在经济中发挥重要作用的地区受到的影响更大。在社会方面，与中国接壤的远东地区由于贸易限制而更加脆弱。由于2020年的疫情，几乎所有地区的经济都受到了影响，特别是拥有数百万居民的城市及其城市群，它们的第三产业也突然被中止了。社会领域对危机的反应最为迅速，而环境部分则并不明显，尽管发生了危机，但仍呈负增长趋势。
结论：对经济落后和经济单一地区的支持措施应以牺牲面向大众消费的产业为代价，从而实现产业多样化。对于专门从事煤炭开采的地区，有必要在无危机时期发展与该行业相关的产业。对于远东地区，主要的支持方案是发展面向中国需求的产业。

关键词
环境风险、可持续发展、社会经济发展因素、俄罗斯地区、综合指数、危机

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Introduction

Stable systems are generally less vulnerable to crises, but such events often reveal their underlying weaknesses. Over the past 15 years, Russia has faced multiple crises, providing valuable experience in navigating these challenges. This makes it particularly relevant to analyze the socio-economic issues experienced by Russian regions during recent crises, including the sanctions crisis following the annexation of Crimea in 2014 and the COVID-19 pandemic. Such an analysis can help identify vulnerable areas that need to be addressed to prevent or minimize the impact of future crises.

In this context, the assessment of regional resilience is necessary in order to determine which regions are more or less likely to suffer during crises, as well as identify the tools and strategies to support them—insights that are critical not only for immediate crisis response but also for fostering long-term resilience and stability.

This study aims to examine the vulnerabilities of sustainable development (SD) components across Russian regions during the crises of the past 15 years. Specifically, the objectives are as follows: develop a regional-level SD index; track changes in this index and its components during crises (starting from 2013); analyze how crises have affected different SD components in various regions; identify the most problematic aspects of SD during crises; and propose policy measures to ensure smoother crisis recovery and enhance regional resilience.

The research focuses on sustainable development and its components, with particular attention to crisis-induced changes and their spatial distribution across Russia's regions. A key challenge lies in defining the components of SD. In this study, sustainable development is understood as the integration of economic growth, social equity, and environmental balance—a framework that supports the well-being of current and future generations (Anisimov et al., 2023).

The study explores the following hypotheses:

1. The economy and social sphere are the most vulnerable components of sustainable development and will play a decisive role in determining the territorial distribution of the most problematic regions during crises.

2. The environmental component of SD will not respond immediately to crisis situations but will gradually deteriorate in the aftermath of crises.

Overall, the study is structured as follows: it begins with a review of research on the concept of sustainable development and the evaluation of its individual aspects at the subnational level in Russia. Indicators are then selected to characterize the specific components of SD, and calculations are performed to derive the SD index and sub-indices representing these components. A classical methodology is applied for constructing the index: each sub-index is based on three indicators, which are normalized and averaged. The overall index is calculated as the mean of its components. The study analyzes changes in the national average values of these indices relative to 2012 and examines the regional distribution of these changes. As a result, the most critical areas and regions are identified, and recommendations are proposed for addressing crisis situations.

Theoretical framework

In both Russian and international academic literature, there are two main approaches to understanding the resilience of economic development (Malkina, 2021). The first approach interprets "sustainable" development as a process accompanied by positive social, economic, and environmental effects. he second approach views "resilience" as the ability of a region to resist internal and external shocks, recover from them, and transition to a qualitatively new trajectory of development (Malkina, 2021).

Within the sustainable approach, there are also diverse perspectives on what constitutes sustainable development (Mensah, 2019). Some researchers define it as a process of improving and maintaining the "health" of economic, environmental, and social systems (Gray et al., 2013; Mensah et al., 2018; Shepherd et al., 2016).

Others argue that sustainable development involves the efficient and equitable allocation of the limited resources of ecosystems, not only within a single generation but also between generations (Stoddart, 2011). The Brundtland Report similarly states that sustainable development meets the needs of the current generation without compromising the ability of future generations to meet their own needs (Schaefer et al., 2005).

Another perspective (Ben-Eli, 2015) defines sustainable development as a dynamic equilibrium, where humanity fully realizes its potential without causing significant negative impacts on the environment.

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Given that the key issues of sustainable development revolve around ensuring economic growth, environmental protection, and social equity (Taylor, 2016), three conceptual pillars can be identified: "economic sustainability," "social sustainability," and "environmental sustainability" (Mensah, 2019).

Economic sustainability is understood as a production system that considers the limitations of natural resources and meets the needs of current generations without compromising the ability of future generations to meet their needs (Lobo et al., 2015). To minimize the negative impact of economic development on the environment and social progress, all aspects of sustainability are taken into account (Zhai et al., 2019).

Social sustainability is defined as ensuring principles of fairness, equal opportunities and rights, and institutional stability in society (Daly, 1992; Gray, 2010; Guo, 2017). This concept focuses on reducing poverty levels (Littig et al., 2005), viewing poverty reduction as a way to also mitigate the negative environmental impacts of inequality (Farazmand, 2016). However, the concept makes clear that poverty reduction must not come at the cost of environmental degradation or economic instability (Kumar et al., 2014; Scopelliti et al., 2018). Social sustainability does not aim to satisfy every individual's needs directly but rather to create conditions where each person can realize their potential (Kolk, 2016).

Ecological sustainability assumes that natural resources are both a source of economic resources and a "sink" for waste. Resources must be extracted at a rate lower than their natural regeneration, and waste must be generated at a rate below nature's capacity to assimilate it (Brodhag, 2006; Goodland et al., 1996; Diesendorf, 2000; Evers, 2018).

The concept of sustainable development is founded on the following principles: the preservation of ecosystems and biodiversity, the maintenance of productive systems, population growth control, human resource management, and the promotion of progressive cultural development (Mensah et al., 2018; Mensah, 2019; Molinoari et al., 2019).

Zemtsov and co-authors (2020) propose a model of sustainable development based on the combination of per capita GRP growth and ecological efficiency, which is defined as the ratio of the output of non-resource goods and services to the costs of resources (labor, capital, raw materials) and environmental costs. Grishina and Polynyev (2020) evaluate the impact of the pandemic crisis on regional socio-economic development. The integral indices used in the analysis were calculated within the framework of the SDGs and include social components (demographic indicators, income levels, employment, environmental condition, social infrastructure) and economic components (innovation and innovative development, infrastructure provision, investments and financial situation, level of economic activity). Klimanov, Kazakova, and Mikhailova (2019) assess the shock resilience of Russian regions by calculating an integral index of regional resilience for each constituent entity of the Russian Federation for the period 2007-2016, based on 17 indicators reflecting comprehensive socio-economic development. Regions with low shock resilience predominantly include those from the Southern, North Caucasian, Siberian, and Far Eastern Federal Districts.

Mikheeva (2021) evaluates the economic resilience of Russian regions by examining the characteristics of economic crises at the regional level. The study analyzes the impacts of the 2009 and 2015 crises on Russian regions and identifies the factors that influenced regional resilience to crisis shocks. To assess these factors based on regional characteristics, the author categorizes the indicators into three groups. The first group consisted of objective regional characteristics, such as the proportion of urban population, transport accessibility, the share of exports in GRP, and the average annual growth rate of the regional economy over the 8 years before the crisis. The second group focused on the population's characteristics and the region's human and innovation potential, including the proportion of poor people, per capita income, and the share of workers with higher or secondary education. The third group covered economic policy parameters, such as the growth rate of investments in fixed capital, the proportion of employees in small enterprises, and per capita social spending from the regional budget.

Globally established approaches to measuring sustainable development can be broadly divided into two categories. The first focuses on developing systems of indicators that assess specific areas, such as the economy or ecology. The second aims to create a single, comprehensive indicator that integrates metrics from various fields. A

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Table 1

Ratings for the assessment of sustainable development and its components at the regional and city levels

Ranking/index	Source	Focus
Ranking of Sustainable Development of Russian Regions and Cities	SGM Agency	Comprehensive: economy, environment, social sphere, institutions.
Regional Quality of Life Ranking	RIA-Rating	Comprehensive: economy, environment, social sphere, infrastructure
Ranking of Fundamental (Environmental-Energy) Business Efficiency	Interfax-ERA	Environmental and energy efficiency of enterprises
Environmental-Economic Index of Russian Regions	WWF of Russia	Environmental and economic
ESG Ranking of Russian Regions	RAEX	Comprehensive: environment, social sphere, administration
National Environmental Rating of Russia's Regions	The Green Patrol Organization	Environmental
SDG Achievement Index of Russian Regions	Center for Spatial Economics of the Institute of Public Administration and Civil Service (IPAE) of RANEPA	Comprehensive
Urban Quality of Life Index	WEB.RF	Comprehensive
European Cities SDG Index	UN SDSN	Comprehensive: economy, environment, social sphere, institutions
Arcadis Sustainable Cities Index	Arcadis	Comprehensive: economy, environment, social sphere, infrastructure, institutions
The Corporate Knights Sustainable Cities Index	Corporate Knights	Environment+infrastructure
US Sustainable Development Report	SDSN USA	Comprehensive: economy, environment, social sphere, institutions
US Greenest States 2023	World Population Review	Environmental
OECD Regional Well-Being	OECD	Comprehensive
Quality of life in European cities	European Commission	Comprehensive

Source: compiled by the authors

hybrid approach is also possible, where indicator systems are aggregated into a unified index. However, this method brings a host of methodological problems, including the aggregation of diverse metrics, the need for consistent statistical tracking, and ensuring alignment with national policy priorities.

Numerous rankings, ratings, and indices have been developed both in Russia and worldwide to address specific aspects of sustainable development—primarily socio-economic or environmental—at the subnational level (see Table 1). A key issue is the lack of comparability, difficulties in verification, and the problems with access to original data to integrate the most successfully analyzed aspects into a more comprehensive index. Developers of international rankings and indices face a number of challenges, particularly in ensuring the comparability of national statistical data.

International academic literature approaches the impact of crises on regional sustainable development from a variety of perspectives. Analysis of a case should consider the following variables: the scale of the crisis (local or global), the nature of the crisis (economic, political, ecological, social), the region's resilience to the crisis, cultural and historical factors, and social capital. Crises can disrupt sustainable regional development by impacting various dimensions, including ecological, social, economic, and political factors. Additionally, the transition to sustainable development on the regional level can be seen as a strategy for combating the crisis.

Method and Data

In this study, the classical method of index construction was applied to assess sustainable development at the regional level. To accurately represent the situation in a particular region, it's best

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Table 2

Indicators included in the sustainable development index for regions of Russia, by sector

	Economic development	Units of measurement
1	Investments in fixed capital per capita (at comparable 2021 prices)	ths rub per capita
2	Gross Regional Product (GRP) per capita, adjusted for the cost of the consumer basket (at comparable 2020 prices)	rub/person.
3	Level of innovation activity of organizations	%
	Social development	
1	Population growth rate	%
2	Taxable monetary income of individuals and individual entrepreneurs (per capita), adjusted for the cost of the consumer basket (at comparable 2021 prices)	ths rub per capita
3	Total residential floor space per capita	sq.meters per capita
	Environment	
1	Emissions of pollutants into the atmosphere from stationary sources and motor transport, as a percentage of GRP	t/ rub.
2	Discharge of polluted wastewater into surface water bodies as a percentage of GRP	cubic meters/rub.
3	Ratio of timber harvesting to forest regeneration	cubic meters/ha

Source: compiled by the authors

to use a small number of meaningful indicators that effectively capture key processes and outcomes. For example, population growth rates are determined by the balance between natural increase and migration. If natural decline is offset by migration, it can indicate the economic attractiveness of a region; conversely, the reverse process suggests a shrinking population reproduction and a relatively less favorable socio-economic environment in the region.

For the calculations, we selected nine indicators, three for each sphere characterizing sustainable development: economic, social, and ecological (Table 2). The data source was the annual publication "Regions of Russia: Socio-Economic Indicators" by the Federal State Statistics Service, which provides updated information for each Russian region.

To assess the level of economic development in regions, we used the classical indicator of Gross Regional Product (GRP) per capita. The prospects for economic growth were examined through investments in fixed capital per capita, and the quality of economic growth, through innovation activity of organizations. This indicator, however, has several methodological limitations that need to be considered. For instance, innovations can be not only product- or technology-based but also process-related, involving changes in business processes, which are more common in large businesses. Furthermore, data on innovation activities are collected through *Form 4 – Innovations*[1], which many researchers consider statistically unreliable (Bortnik et al., 2013). The statistics are often significantly underestimated because businesses are reluctant to fill out the form due to the high labor costs involved, leading them to enter zero values across all fields.

For the social sphere, we used population growth rates and taxable income as indicators. To assess living conditions, we considered the amount of living space per capita, which reflects both the rate of new housing construction and population density in the region.

The environmental indicators used in this study correspond to various types of pollution. First, we included indicators of air pollution from both stationary and mobile sources, which allowed us to consider regions with large industrial enterprises as well as those without significant stationary pollutants but with high population density. To assess water quality, we used the indicator of polluted water discharge into surface water bodies and thus identified regions with major industrial enterprises, large urban centres, or outdated and underdeveloped infrastructure. To ensure comparability, all indicators were standardized by Gross Regional Product (GRP). The third indicator, the ratio of timber harvesting to forest restoration, may be less relevant for the Far North

[1] *Form 4 – Innovations* is a reporting form used by Rosstat to collect data on innovation activities of organizations.

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and southernmost regions but can be useful for most other regions, as it reflects the impact on forest ecosystems.

Since the standard of living varies widely across Russian regions, all monetary indicators, except for investments in fixed capital, were adjusted by the cost of the consumer basket. This coefficient was calculated by comparing the cost of a standard consumer basket in a region to its average cost across the country.

Each indicator was normalized using linear scaling. Environmental indicators with an "inverse" relationship—meaning that higher values indicate worse outcomes—were normalized as follows: for all other indicators, 1 represents the best value and 0 the worst, while for environmental indicators, the values were reversed. The SD index was calculated by averaging three indicators for each sphere, which were then further averaged. To analyze comparable dynamics, the calculations were based on 2012: the maximum values from 2012 were assigned a score of 1, and the minimum values were assigned a score of 0.

As a result, each region received a normalized score between 0 and 1. To analyze the overall trends in the sustainable development score and its components across the regions, the average scores for all regions were calculated.

Cities of federal significance (Moscow, St.Petersburg, and Sevastopol) were excluded from our analysis, as comparing large centers with other regions is not entirely appropriate in terms of comparability. The Republics of Chechnya and Ingushetia, as well as the Khanty-Mansi Autonomous District, were excluded due to the lack of data on the dynamics of certain indicators.

Results and Discussion

Dynamics of sustainable development components: The calculation of the SD index relative to 2012 shows that after a decline in 2015, the index stagnated until 2018, which was followed by a drop in 2020. However, since no significant changes occurred in the index compared to 2012, it can be concluded that regions have shown little to no progress toward a sustainable development trajectory (Figure 1).

The dynamics of the "Economic development" subindex closely mirror the overall index, although while the decline in both values due to the 2014 crisis is comparable, the drop in the subindex reflecting the level of economic development in 2020 is much more severe, surpassing both the 2014 effect and the overall index decline (Figure 2).

The dynamics of individual components show that the "Investments in fixed capital" indicator was most strongly affected by the 2014 crisis and did not recover afterward, continuing to decline almost every subsequent year. The GRP per

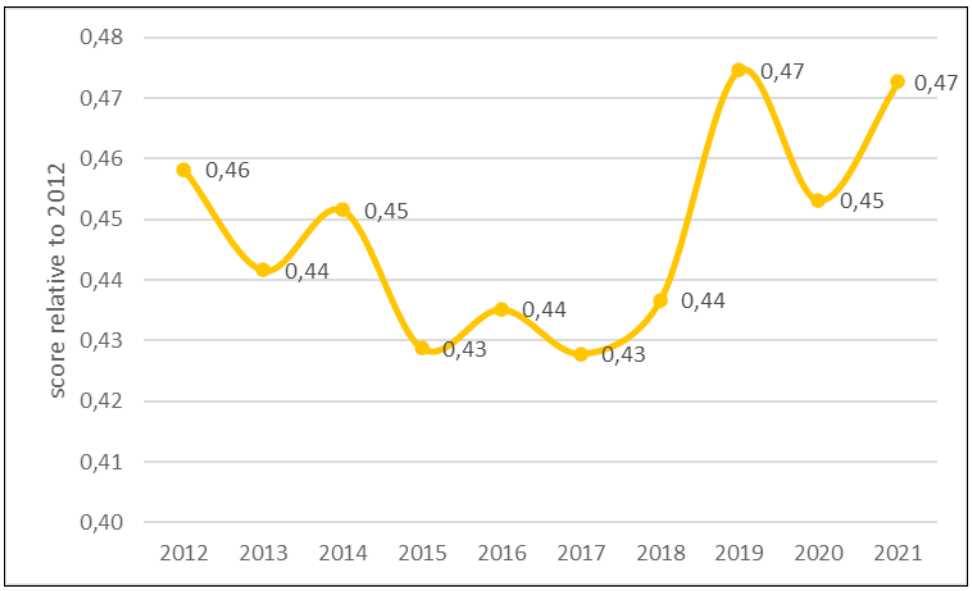

Figure 1. *Dynamics of the SD index relative to 2012*

Source: the authors' calculations are based on Rosstat data, statistical yearbook "Regions of Russia. Socio-economic indicators". Accessed: 22.07.2023.

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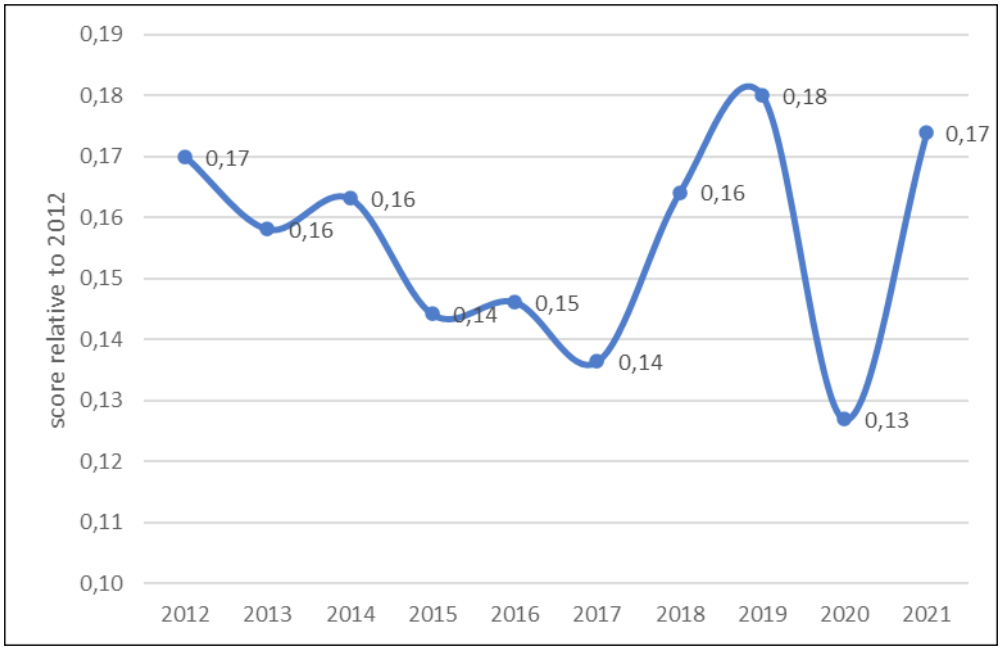

Figure 2. *Dynamics of the "Economic development" sub-index.*

Source: the authors' calculations are based on Rosstat data, statistical yearbook "Regions of Russia. Socio-economic indicators". Accessed: 22.07.2023

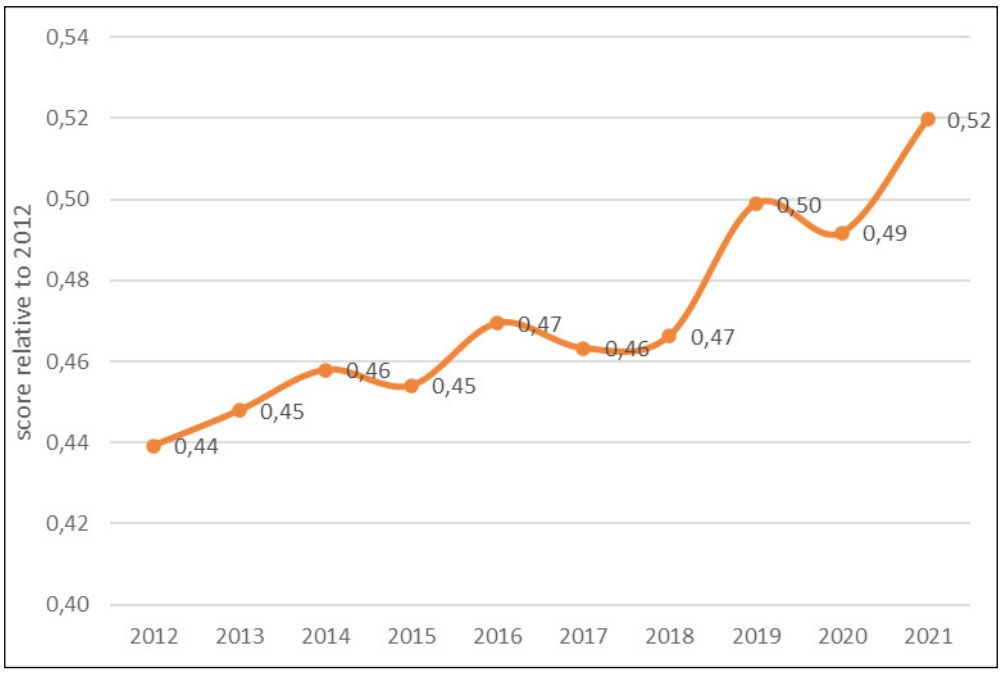

Figure 3*. Dynamics of the "Social development" sub-index.*

Source: the authors' calculations are based on Rosstat data, statistical yearbook "Regions of Russia. Socio-economic indicators". Accessed: 22.07.2023

capita indicator reacted more significantly to the pandemic, shifting from modest growth to a decline, which was subsequently offset by a recovery in 2021.

The most significant fluctuations are observed in the level of innovation activity among organizations. Although it mainly shows negative changes after 2014, this indicator grew steadily until 2020. Unfortunately, the methodology for this indicator raises several questions (see above), making it difficult to explain its dynamics definitively. However, the sharp decline in this indicator in 2020 like-

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ly reflects a decrease in business activity during that period, a trend also observed after 2014.

Negative changes in the social component of the index are less noticeable, as they are offset by the overall positive trend (Figure 3). In this case, the values of the sub-index for each specific year are more indicative, as they reflect the general decline in household incomes. The social component also showed a decline and stagnation in 2014, and a decrease in 2020. However, the decline in the social component, unlike the economic one, is less pronounced than that of the overall index: the pandemic's impact on the regions primarily affected the economy.

Among the indicators comprising the "Social development" sub-index, tax revenues from the population are the most sensitive to crises. These revenues significantly decreased starting from 2014 but returned to modest growth rates by 2016 and continued to show positive dynamics even in 2020. This trend is attributed to active regional and federal policies aimed at maintaining household incomes during the pandemic. The most stable indicator is the growth in residential area per capita, although this growth is largely driven by major cities.

The population growth shows a general downward trend, which is linked to demographic processes in the regions, such as the entry into childbearing age of the relatively small cohort born in the 1990s. Additionally, the trend can partly be explained by declining birth rates amid a more challenging economic environment, leading to uncertainty in family planning. The decline in population numbers in 2020 can be explained by increased mortality during the pandemic.

The environmental component exhibits a downward trend—while the sub-index value was 0.77 in 2012, it dropped to 0.72 by 2021 (Figure 4). This decline persisted throughout most of the period, with the exception of three specific intervals, and significantly intensified during the following crises. The overall trend remains negative.

The components of the *"Environment"* sub-index generally remained stable throughout the analyzed period. However, each indicator proved sensitive to crises, showing negative dynamics in response to the 2014 crisis.

These patterns were not observed in 2021, which can be attributed to the specific nature of the crisis. Due to the increase in disease incidence

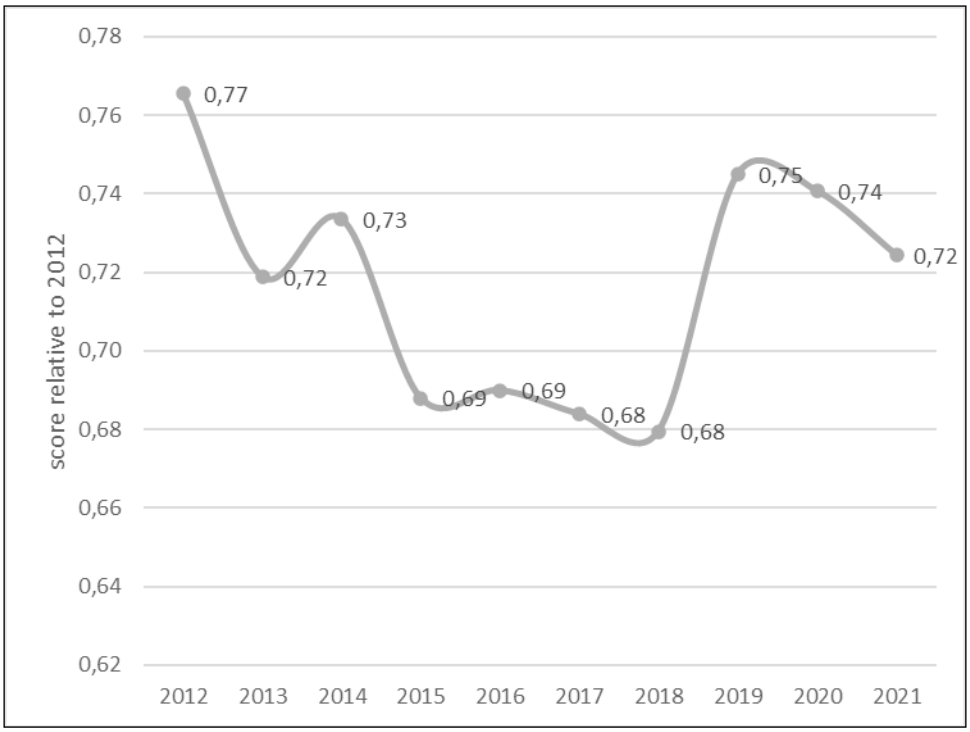

Figure 4. *Dynamics of the "Environment" sub-index.*

Source: the authors' calculations are based on Rosstat data, statistical yearbook "Regions of Russia. Socio-economic indicators". Accessed: 22.07.2023

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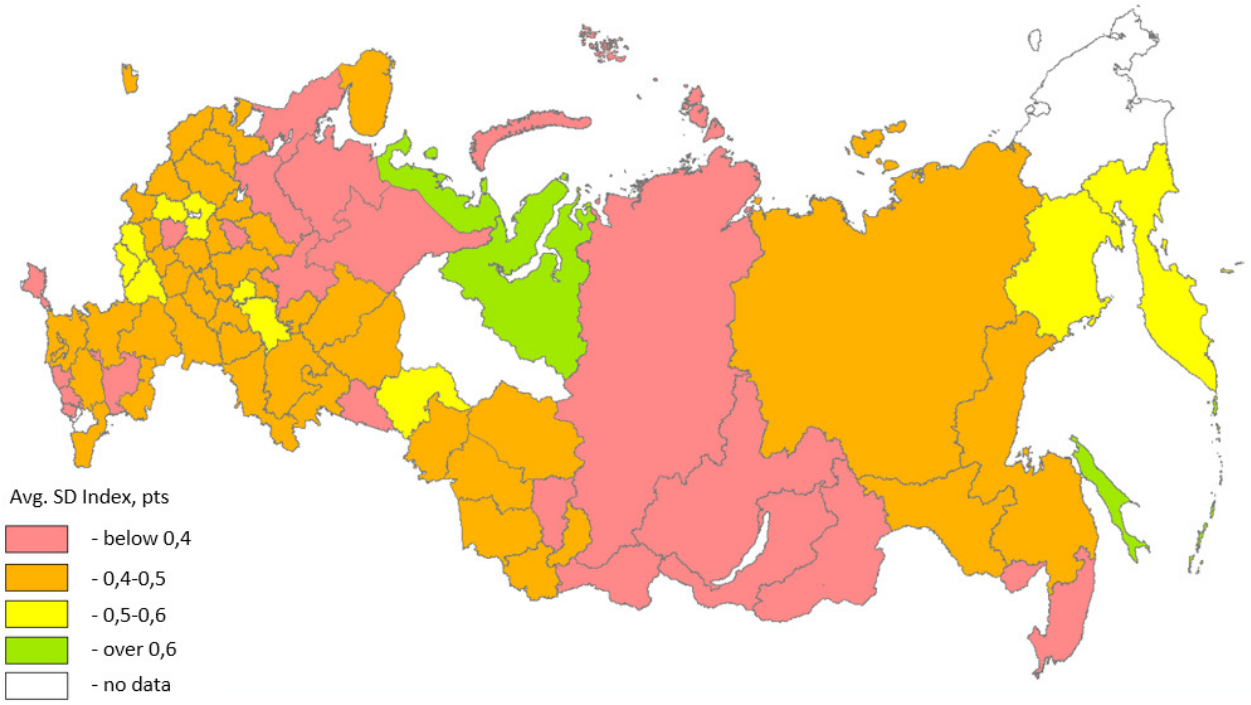

Note: The borders of the Russian Federation are shown as they were during the periods of the crises in 2014 and 2020.

Figure 5. *Average value of the SD index for 2012–2021*

Source: the authors' calculations are based on Rosstat data, statistical yearbook "Regions of Russia. Socio-economic indicators". Accessed: 22.07.2023

and subsequent anti-epidemic restrictions, production levels declined, leading to a reduction in emissions.

The only indicator that exhibited consistently negative dynamics throughout the analyzed period was the ratio of pollutant emissions to GRP. Although the increase in 2019 was statistical, the overall trend suggests a deceleration in the rate of decline.

Analysis of the selected indicators suggests that among the three components of sustainable development, the economic component is the most sensitive to crises. The environmental component experiences smaller-scale declines but demonstrates long-term negative trends. Social development is also impacted by crisis; however, Russian regions exhibit an overall positive trend in this sub-index primarily due to indicators such as "Taxable monetary incomes of individuals and sole proprietors (per capita), adjusted for the cost of the consumer basket (in comparable 2021 prices)" and "Average residential area per capita."

Regional differences in the dynamics of the SD index: Northern regions specializing in natural resource extraction scored highest in the SD index for 2012–2021 (Figure 5). These include the three highest-ranking regions (Yamalo-Nenets and Nenets autonomous districts, and Sakhalin region) and a third of the regions in the higher-score group (e.g., Tyumen and Magadan regions).

Magadan region stands out due to its low population density, high economic performance, and reliance on hydropower. However, it also experiences significant environmental pressure, particularly from dredging and open-pit mining for gold and other minerals, which are not covered by the indicators included in the index.

Another group of regions with high scores comprises central regions with developed industries and agriculture (e.g., Moscow, Kaluga, Belgorod, and Voronezh regions), excluding the Republic of Tatarstan. A similar situation is observed in Kursk and Belgorod regions, where iron ore extraction is carried out in the Kursk Magnetic Anomaly.

The comparison of this approach and its results with other SD rankings has brought us some interesting observations. Other rankings tend to use a larger number of indicators reflecting various aspects of sustainable development. Never-

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theless, the results we obtained are largely consistent with those of our colleagues. The similarity in results may support the validity of our approach, which uses fewer indicators, making it simpler to apply.

The leading regions in our calculations largely align with the findings of colleagues from the SGM agency[2]. However, due to higher living standards, southern regions also rank among the top, while some regions in the Far East drop out of the leading positions. The lagging regions are mostly consistent across rankings, which points to both objectively low economic and social indicators in these areas and statistical nuances in some of them (e.g., the republics of the North Caucasus and southern Russia, Tuva Republic, Jewish Autonomous Region, Pskov Region, etc.). However, some regions we identified as leaders are laggards in SGM rankings, primarily due to factors such as innovation and living conditions. One significant methodological distinction of the SGM ranking is that it's based not on raw indicators but on the positions of regions in specialized rankings compiled by other organizations (e.g., RAEX, AIRR, Skolkovo School of Management, HSE University). Additionally, it distinguishes innovation and digitalization as a separate measurable aspect of development.

In contrast to our methodology, the RAEX ranking[3] focuses on regions' exposure to risks across various domains and their capacity to mitigate them. This approach involves pairing indicators, with one representing a risk and the other representing a means of reducing it. The ranking incorporates 24 indicators in total. This focus results in outcomes that differ somewhat from ours. For example, insufficient emphasis on the economic component places regions like Tver and Irkutsk and the Chuvash Republic in the top ten, with the Republic of Tatarstan as the leader. Meanwhile, Magadan and Kamchatka regions, which we classify as regions with high SD, are positioned as laggards in the RAEX ranking due to prolonged outflows of human capital. Similarly, many regions specializing in oil, coal, and metallurgy—industries with high emissions and comparatively low capture rates—are also classified as laggards in this ranking.

The Environmental-Economic Index of Russia's regions[4] is based on the calculation of the adjusted net savings index, which is correlated with the region's GRP. This index is determined by subtracting investments in the extractive sector, as well as the depletion of natural resources and environmental damage caused by economic activities, from gross fixed capital formation. At the same time, it adds expenditures on human capital development, environmental protection, and the positive contribution of protected natural areas (PNAs). Since resource depletion is a key component of the index, regions that are heavily reliant on resource extraction for export generally do not rank among the leaders. However, regions specializing in the extraction of non-fuel mineral resources tend to perform better and often rank near the top. This trend aligns with our findings, where regions such as Magadan and Kamchatka are ranked in the top twenty. Interestingly, many regions with less developed economies, which traditionally fall into the "outsider" group, such as the Chechen Republic, the Republics of Ingushetia and Tuva, and the Jewish Autonomous Region, are also among the leaders.

The orientation of the RIA rating[5] leads to some differences in results compared to our assessment. Unlike our approach, which focuses on sustainable development, the RIA rating emphasizes quality of life. Its methodology encompasses a broader set of indicators (70), assessing 11 aspects of quality of life, including factors not accounted for in our sustainable development framework, such as climatic conditions, housing quality, and residential safety.

Despite some overlap among the leading regions of Central Russia and the Volga Region (e.g., Moscow, Belgorod region, the Republic of Tatarstan), regions like Krasnodar and Kaliningrad are also at the top of the RIA rating. However, resource-extracting regions in the north and northeast, such as the Nenets and Yamalo-Nenets

[2] Ranking of Sustainable Development of Regions of the Russian Federation. SGM Agency: [website]. Available at: https://agencysgm.com/ratings/ (accessed: 21.05.2024)

[3] ESG Ranking of Russian regions// RAEX Rating Group: [website]. Available at: https://raex-rr.com/ESG/ESG_regions/ESG_rating_regions/2021/ (accessed: 21.05.2024)

[4] Bobylev S.N. et al. Environmental-Economic Index of Russian Regions // WWF Russia, RIA Novosti: [website]. Available at: https://rnei.de/wp-content/uploads/2013/09/index.pdf (accessed: 21.05.2024)

[5] Ranking of Russian Regions by Quality of Life — 2023 // RIA Novosti: [website]. Available at: https://ria.ru/20240212/kachestvo_zhizni-1926120093.html (accessed: 21.05.2024)

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autonomous districts, Kamchatka and Magadan regions, cannot lead in such a rating.

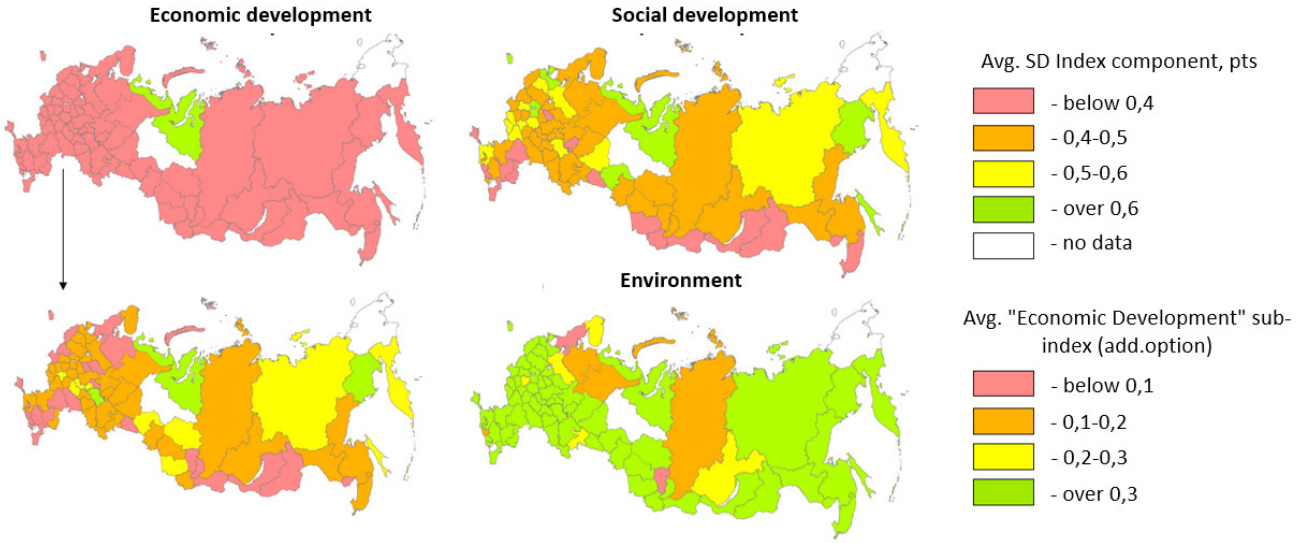
Among these, the Yamalo-Nenets Autonomous District has the highest score, due in part to its relatively high corporate social expenditures. The economic and social differences between regions, as well as variations in environmental conditions, become clearer when we analyze specific components of our index. Figure 9 demonstrates that the gap between the Nenets and Yamalo-Nenets autonomous districts and other regions in the "Economic Development" sub-index is so significant that standardized group classification used for all sub-indices (as shown in Figure 6) does not apply, as it relegates all other regions to the "outsider" category. This does not reflect the actual situation. Therefore, it is necessary to introduce an additional classification scheme for the "Economic Development" sub-index to better highlight regional differences. Regions specializing in mineral extraction (oil, gas, gold), some metallurgical regions (e.g., Lipetsk region), and regions with diversified industries (e.g., the Republic of Tatarstan) exhibit high values in the "Economic Development" sub-index, which cannot necessarily be interpreted as a shift toward sustainable development.

Regions with high values in the "Social Development" sub-index are characterized by either high incomes or favorable agro-climatic conditions. Examples of the former include Tyumen and Moscow regions, while the latter include Voronezh, Kursk, and Belgorod regions.

Regions with low values in the "Environment" sub-index include those with developed metallurgy (e.g., Krasnoyarsk and Chelyabinsk regions), open-pit coal mining and coal energy production (e.g., Kemerovo and Krasnoyarsk regions), and the pulp and paper industry (e.g., Arkhangelsk region). These industries are among the largest contributors to environmental emissions.

The 2015 crisis had a particularly negative impact on coal-mining regions oriented toward exports (Figure 6). These regions proved less resilient to the crisis caused by sanctions because coal is easier and faster to phase out compared to other types of fuel resources. Additionally, the global shift toward "green" policies has led to a general decline in the demand for thermal coal, which means that these regions need to gradually explore and develop new economic specializations. The most resilient regions in this period were those in the central European part of Russia, as many of them focus on meeting domestic demand, including that of large urban agglomerations.

After 2020, declines in the index were more influenced by institutional factors, such as decisions made by local leaders. However, the regions



Note: The borders of the Russian Federation are shown as they were during the periods of the crises in 2014 and 2020.

***Figure 6**. Values of the components of the SD index for 2012–2021*

Source: the authors' calculations are based on Rosstat data, statistical yearbook "Regions of Russia. Socio-economic indicators". Accessed: 22.07.2023

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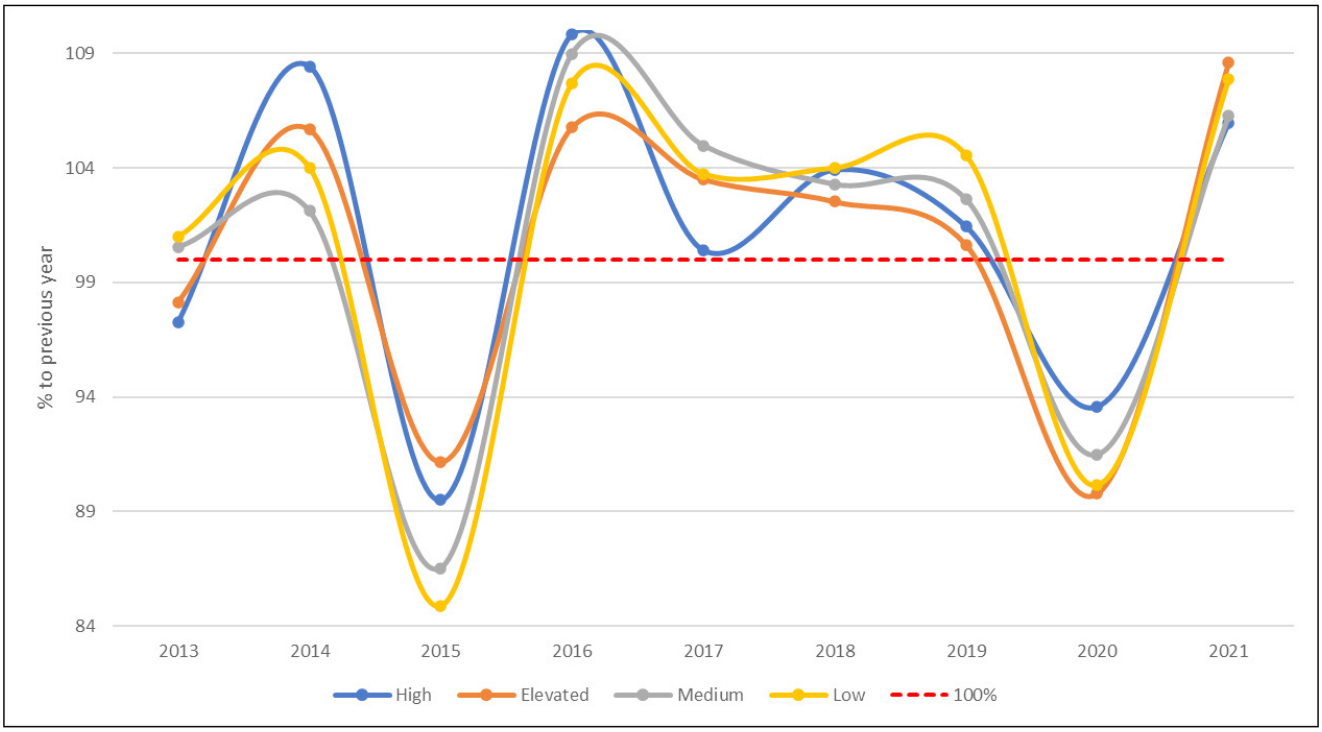

Figure 7. *Dynamics of sustainable development index values in regions of different groups, 2013–2021*

Source: the authors' calculations are based on Rosstat data, statistical yearbook "Regions of Russia. Socio-economic indicators". Accessed: 22.07.2023

most affected were those with major cities (due to closures in the tertiary sector and reduced industrial activity) and regions bordering China (due to border closures).

An analysis of the SD index dynamics across regional groups confirms that regions with higher index values are more resilient to crises, which is reflected in smaller fluctuations and less pronounced declines in the index during crisis years (Figure 7). The least resilient regions are those with lower index values, partly due to the "low base" effect. However, during crises, the greatest declines are observed in regions with low or average index values, which comprise the majority of the regions in question.

Regions with above-average index values also exhibit greater resilience. However, in 2020, these regions experienced declines of similar magnitude to those of the two lower-tier groups, due to the suspension of economic activities. The top-performing group was an exception, as their resource-based economies allowed mining activities to continue without interruption during this period. Over the analyzed period, the growth of the index decreases with each successive group: regions with high SD index values saw a 12% growth, those with above-average values grew by 7%, regions with average values grew by 3%, while regions with low index values experienced a decline.

From the perspective of the "Economic development" sub-index, the 2014 crisis primarily affected either export-oriented regions or those with established industrial ties to foreign countries (Figure 8). During the 2020 crisis, nearly all regions faced economic challenges due to widespread suspension of economic activities.

The social component appeared less vulnerable during both crises compared to other sub-indices. However, slower declines in the index do not imply an absence of issues. For instance, during the crises, far eastern regions bordering China showed lower resilience, and in 2020, regions with million-plus cities or their agglomerations were hit harder. For the sub-index measuring environmental conditions, it is difficult to separate the impact of the crises from the ongoing negative trends. The most significant negative changes occurred in regions already facing severe environmental issues. This underscores the need for targeted policies in these areas, which should include not only penalties but also incentives to

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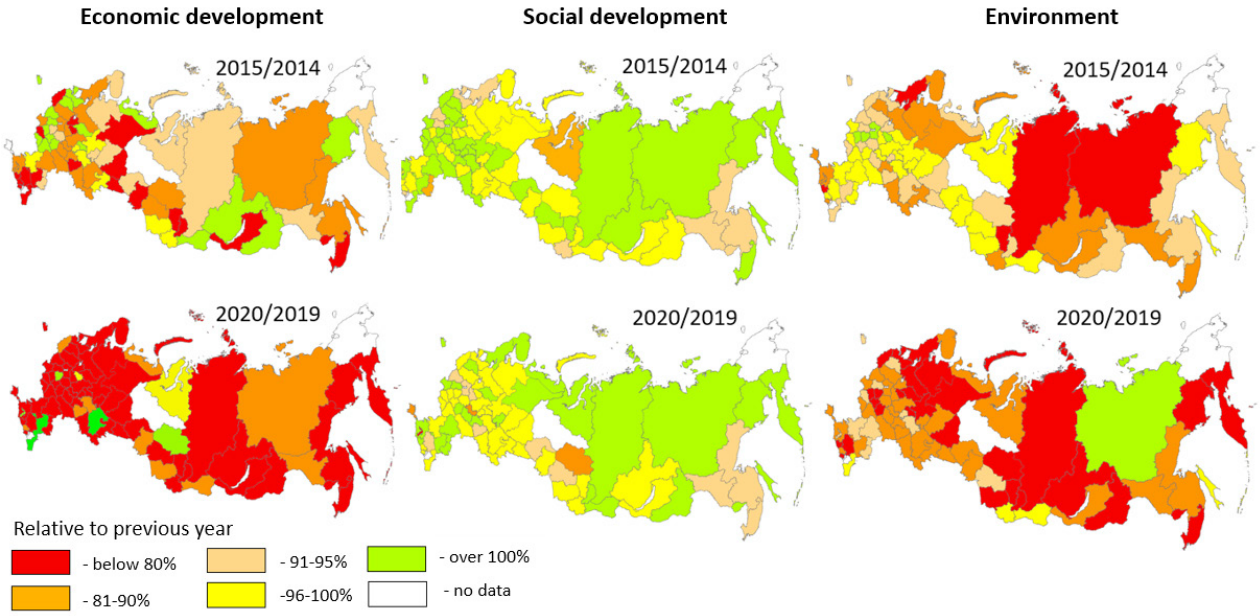

Figure 8. *Changes in the components of the SD index in the crisis periods of 2014–2015 and 2019–2020*

Source: the authors' calculations are based on Rosstat data, statistical yearbook "Regions of Russia. Socio-economic indicators". Accessed: 22.07.2023

encourage businesses to adopt more environmentally responsible practices.

Conclusion

This study analyzed SD index dynamics to identify regional crisis response patterns, confirming the initial hypotheses and providing insights into the current situation.

The sanctions imposed on Russia in 2022 and their ongoing intensification can be compared to the 2014 crisis, induced by the Crimea-related sanctions. The economic component of the index may show a decline, primarily due to the drop in investments in fixed capital. Our analysis revealed that this indicator significantly decreased after 2014. However, the reduction in foreign investments could be offset by government funding directed at the defense industry. Given the widespread presence of defense-sector enterprises across the country, this has a notable positive economic impact, partially compensating for the decrease in foreign investment. The increased volume of orders for these enterprises, however, is likely to negatively affect the environmental component of the index, as these industries are not focused on environmental efficiency.

The environmental indicators are the most resilient, which can be explained by their inertia: for negative changes to manifest, a crisis situation must last more than one or two years. In the context of the current crisis and significant restrictions on technology imports from developed countries, the environmental sector is expected to face clear negative consequences, primarily due to limitations on the use of foreign filtration and purification technologies.

The social sphere reacts most visibly to crises, due to the sharp decline in real disposable incomes in such periods. This is also a common strategy for Russian businesses to maintain profitability during crises, often involving significant cuts to incentive payments while only official wages are retained. The recovery of this indicator is also slow and requires at least two years. The experience of the pandemic showed the need for prompt action from the government: access to financing should be simplified, and social support measures should be introduced.

Systematic measures are needed for the environmental component, including not only penalties for businesses that violate regulations but also positive incentives to support businesses in improving their environmental efficiency, for example, tax breaks.

Regions with a low SD index, which are the most vulnerable during crises, require greater support to promote industries oriented toward mass domestic consumption. Additionally, specialized

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support measures are necessary to reduce economic monocentricity in coal-mining regions and in the regions of Russia's Far East bordering China.

Our findings can be used to develop tailored support strategies for different types of regions. Regions with underdeveloped and monocentric economies require industrial diversification by fostering industries that are relatively easy to enter and focus on mass consumption.

Coal-mining regions, with their economic reliance on a single industry, prove extremely vulnerable during crises in Russia. In this case, a comprehensive program for developing alternative industries is essential in periods of stability. These efforts should focus on coal-related machinery manufacturing and maintenance industries, as there will continue to be a demand for equipment in the mining sector, making it a niche yet essential specialization for these regions.

Another group of vulnerable regions is the Russian Far East, especially those bordering China, where the primary support strategy focuses on developing industries aimed at meeting Chinese demand. This approach not only fosters economic growth in these regions but also creates a foundation for further diversification efforts.

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Application of the concept of technological maturity in regional industrial development strategy-making

ABSTRACT
Relevance. Technological sovereignty in the national economy cannot be achieved without a clear understanding of the state of regional industries, particularly their level of technological maturity. This crucial factor drives investment decisions and shapes regional development strategies. However, existing methods for assessing technological development often fail to account for industries' reliance on foreign technologies and services.
Research Objective. The study explores the concept of technological maturity in the context of managing regional industrial development, focusing on the case of regional industries in Russia.
Data and Methods. To evaluate the technological maturity of regional industries, we propose an index derived from normalizing key indicators that capture the critical aspects of technological maturity. The normalized indicators are aggregated using the arithmetic mean. Correlation analysis was employed to identify factors influencing technological development. The study is based on official statistics from the Federal State Statistics Service (Rosstat) for 2022.
Results. Technological maturity indices are calculated for Russian regions, identifying both strengths and weaknesses. Only nine regions have achieved a medium level of technological maturity, while most remain at low levels. Additionally, many regions leading in terms of technology are highly reliant on imported technologies and services, with minimal exports of domestically developed technologies. These results highlight the need for policy measures tailored to regions' varying needs and levels of technological maturity.
Conclusions The concept of technological maturity provides a strategic framework for regional industrial development that can enhance national economic competitiveness through both embracing modern technologies and ensuring technological independence. The technological maturity index provides a valuable tool for tracking key indicators of technological sovereignty in domestic industries and identifying investment priorities to strengthen it.

KEYWORDS
regional industry, technological sovereignty, regional development strategy, technological maturity index, industrial economics, investment

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Применение концепции технологической зрелости в стратегии промышленного развития региона

АННОТАЦИЯ
Актуальность. Задачи достижения технологического суверенитета национальной экономики предполагают необходимость понимания уровня технологической зрелости промышленности регионов, поскольку от этого зависят масштабы и направления инвестиций, отражаемых в содержании региональных стратегий. Современные подходы к оценке уровня технологического развития промышленности не учитывают, в какой мере она зависима от зарубежных технологий и услуг технологического характера.

КЛЮЧЕВЫЕ СЛОВА
промышленность региона, технологический суверенитет, стратегия регионального развития, индекс технологической зрелости, экономика промышленности, инвестиции

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Цель исследования состоит в обосновании целесообразности использования концепции технологической зрелости в стратегическом управлении процессами промышленного развития региона. Объектом исследования выступает промышленность российских регионов.
Данные и методы. Для оценки уровня технологической зрелости промышленности региона предлагается индекс, построенный путем нормализации значений показателей, отражающих наиболее значимые факторы технологической зрелости промышленности, с последующим их агрегированием на основе процедуры среднего арифметического. Для проверки выявления факторов, влияющих на технологическое развитие промышленности использован корреляционный анализ. Исходные данные исследования представленными официальными данными Федеральной службы государственной статистики за 2022 год.
Результаты. Определены индексы технологической зрелости российских регионов и выделены их лидирующие и слабые позиции. Определено, что только девять российских регионов имеет средний уровень технологической зрелости, остальные характеризуются низким уровнем. Выявлено, что большинство регионов технологических лидеров отличаются высокой зависимости от импорта технологий и услуг технологического характера при низких объемах экспорта собственных технологий. Предложены меры региональной политики в зависимости от уровня технологической зрелости промышленности.
Выводы. Сделан вывод о том, что применение концепции технологической зрелости в стратегии промышленного развития региона позволяет акцентировать внимание на том, что повышение конкурентоспособности российской экономики определяется не только уровнем использования современных технологий, но и уровнем технологической независимости производства. При этом использование индекса технологической зрелости позволяет отслеживать изменения контрольных показателей достижения технологического суверенитета отечественной промышленности, а также увидеть направления инвестирования для его укрепления.

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技术成熟度概念在地区工业发展战略中的应用

摘要
现实性：实现国民经济技术主权意味着要了解地区工业的技术成熟度，因为地区战略中的投资规模和方向取决于此。评估工业技术发展水平的现代方法没有考虑到工业对外国技术和技术服务的依赖程度。
研究目标：目的是证实在地区工业战略发展进程中应用技术成熟度概念的可行性。研究对象是俄罗斯各地区工业。
数据与方法：为了评估该地区工业的技术成熟度，我们提出了一个指数，该指数对工业技术成熟度的最重要指标值进行归一化处理，然后根据算术平均法对其进行汇总。相关分析用于验证影响工业技术发展的因素。研究的初始数据来自联邦国家统计局 2022 年的官方数据。
研究结果：确定了俄罗斯各地区的技术成熟度指数，并强调了其领先和落后地区。结果表明，俄罗斯只有九个地区的技术成熟度达到平均水平，其余地区的技术成熟度均较低。结果显示，大多数技术领先地区的特点是高度依赖进口技术和技术服务，而自身技术的出口量较低。文章根据工业的技术成熟度水平，提出了地区政策措施。
结论：在地区工业发展战略中应用技术成熟度的概念使我们明白，俄罗斯经济竞争力的提高不仅取决于现代技术的使用水平，还取决于生产技术的独立性水平。同时，利用技术成熟度指数，我们可以跟踪国内工业技术主权的基准变化，并了解加强技术主权的投资方向。

关键词
地区工业、技术主权、地区发展战略、技术成熟度指数、工业经济、投资

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Introduction

Amid rising socio-economic and geopolitical turbulence, there has been a surge of interest among both scholars and practitioners in finding new approaches to implementing regional industrial development strategies. These strategies aim to help key industrial sectors achieve new levels of technological leadership. President Vladimir Putin has identified industrial policy aimed at achieving technological sovereignty as a key priority for national development, emphasizing the need for innovation-driven renewal of traditional industries and growth of the high-tech sector[1]. To achieve this goal, however, it is necessary to assess the readiness of regional industries for technological change, as this will determine the scale and direction of investments in regional industrial development. As Sukharev aptly notes, the tools for managing technological substitution must account for the current level of technological sophistication (Sukharev, 2024). Thus, to manage development more effectively, it is necessary to measure and assess the technological maturity of industrial sectors.

The concept of technological maturity is relatively new in Russian academic discourse. Recent studies in this field employ a technological maturity index to assess the characteristics and applications of technologies in different countries (Balkan & Akyüz, 2023; Suprun et al., 2024). In Russia, the National Rating of Scientific and Technological Development of Regions, based on the index of the same name, is widely used (Yegorov & Kovrov, 2023). However, these indices do not consider whether the technologies are imported or domestic, whether they replicate foreign counterparts, or if they are entirely new innovations. They also fail to account for how dependent a region's industrial production is on imported technologies and technical services. As a result, existing methods for measuring the technological development of the national economy are not fully aligned with the goal of achieving technological sovereignty.

The above considerations highlight the relevance of this study, which aims to justify the feasibility of the concept of technological maturity in the strategic management of regional industrial development. The structure of the article corresponds to the following objectives:

– review the academic literature on «technological maturity» and define its relevance to regional industry;

– develop tools to assess the technological maturity of regional industries;

– assess the technological maturity of Russian regional industries and identify influencing factors;

– formulate recommendations for policy-makers based on the assessment of regional technological maturity

Theoretical framework

The indicator used to assess the level of technological maturity of an economic system, known by the abbreviation TRL (Technology Readiness Level), was first proposed in the 1960s by the U.S. National Aeronautics and Space Administration (NASA) to evaluate the development level of its technologies[2]. The level of technological maturity is defined according to ISO 16290, which, despite being created for the aerospace sector and primarily focused on IT technologies, has found wide application across various industries (Rocha et al., 2022; Salvador-Carulla et al., 2024; Solis & Silveira, 2020). According to ISO 16290, the TRL indicator can be used to compare different types of technologies by considering the capabilities they offer and their level of effectiveness. The TRL calculator standardizes the assessment of alternative technologies, identifying improvements needed to advance maturity and highlighting the importance of each analyzed area (political-legal, economic, etc.) (Altunok & Cakmak, 2010).

An important feature of the TRL indicator as a tool for assessing technological maturity is that it primarily functions as a micro-level project management tool in the development of specific products. It provides potential investors with information about the stage the technology has reached in the development process and how many more stages remain before the research results can be commercialized, indicating how far the develop-

[1] Government Decree of the Russian Federation No. 603 dated April 15, 2023, «On Approving the Priority Areas for Technological Sovereignty Projects and Structural Economic Adaptation Projects in the Russian Federation» // Official Website of the Government of Russia. Available at: http://government.ru/docs/48272/

[2] NASA (2020) *Systems Engineering Handbook*, Washington, D.C.: NASA // Official NASA website. Available at: https://www.nasa.gov/connect/ebooks/nasa-systems-engineering-handbook

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ment is from market release. Drawing on the concept of a project lifecycle, the TRL methodology includes 9 levels of readiness, ranging from «Basic principles observed and reported» to «Actual system proven through successful mission operations» (Lemos & Chagas, 2016). However, as emphasized by Uflewska et al. (2017), technological maturity reflects not only the stage at which the technology is in the process of moving to the market but also its compliance with specific requirements from the «user.»

However, meso- and macro-level systems are also dependent on technological development and, to achieve development goals, must also employ certain technologies. To better understand these interconnections, the concept of technological maturity has been introduced to describe specific markets, industries (Abramov & Andreev, 2023; Noh et al., 2023; Pinto et al., 2023; Sipthorpe et al., 2022), as well as regions and cities (Damianou et al., 2023; Haraguchi et al., 2024; Nikitaeva et al., 2022)

For example, J. Silberer et al. (2023) propose a conceptual model of market maturity that encompasses both the objective characteristics of a product's technological readiness and the consumer's subjective perspective, emphasizing factors such as «performance expectancy» and «effort expectancy.» The market maturity of e-commerce in EAEU countries is analyzed by Zhanbozova et al. (2021) - their study proposes an integrated readiness index that reflects factors like physical and financial accessibility, digital skills of the population, availability of supporting infrastructure, and more. Zuluaga et al. (2024) propose a model to measure technological maturity, assessing critical industries' readiness for innovation and aiding risk management throughout process life cycles. To evaluate the maturity of public technologies, the GovTech initiative developed a specialized index that includes improvements in the quality of public services, the functioning of government systems, and related areas (Degtyarev, 2022; Bharosa, 2022).

Indicators of maturity are increasingly applied across various activities and domains because they are effective tools for making investment decisions. Researchers frequently assess technological maturity from the perspective of Industry 4.0 development, introducing terms such as «digital maturity index» and «intellectual maturity index.» These terms underscore the pivotal role of digital technologies in defining the frontiers of technological progress (Ovchinnikova & Kharlamov, 2022; Gajdzik, 2022; Chernova et al., 2023; Ferreira et al., 2024; Xing et al., 2024). For instance, the OECD developed a composite index that considers factors such as whether organizations use CRM and ERP systems, have websites, allow online orders, and more (Balkan & Akyüz, 2023).

A similar approach is used in Russia to create indicators for assessing national economic development[3]. Since 2023, an intellectual maturity index has been calculated for various industries, social sectors, and public administration, with a focus on the level of artificial intelligence use in national socio-economic development[4]. As part of strategic planning, various rankings of Russian regions are compiled, including the National Ranking of Scientific and Technological Development, which evaluates government efforts to support R&D in technological domains of science and their effectiveness using a corresponding index[5]. Volkova and Romanyuk (2023) propose a scientific and technological development index focused on infrastructure and digital technology use.

A common limitation of current methods for defining indices that measure the technological maturity of socio-economic systems (including industrial sectors) is that they fail to consider the origin of the technologies in use—whether they result from domestic technological advancements, local innovations, or the adoption of foreign technologies. Moreover, in most cases, these indices focus primarily on digital technologies, overlooking the considerable diversity of other advanced technologies—such as nanotechnology, robotics, energy technologies, and cognitive technologies—used across various industrial sectors.

[3] Indicators of the digital economy. Official website of the Higher School of Economics. Available at: https://www.hse.ru/primarydata/iio (accessed 15.06.2024)

[4] Source: Index of Intellectual Maturity of Economic Sectors, Social Sphere, and Public Administration. Analytical report. 2023. National portal «Artificial Intelligence of the Russian Federation». Available at: https://ai.gov.ru/knowledgebase/infrastruktura-ii/2023_indeks_intellektualynoy_zrelosti_otrasley_ekonomiki_sektorov_socialynoy_sfery_i_sistemy_gosudarstvennogo_upravleniya_rossiyskoy_federacii_ncrii_pri_pravitelystve_rf/ (accessed 15.06.2024)

[5] National ranking of scientific and technological development of the subjects of the Russian Federation. Official website of the Ministry of Education and Science of Russia. Available at: https://minobrnauki.gov.ru/Методология.Национальный%20рейтинг%20НТР.pdf (accessed 15.06.2024)

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Table 1

Levels of technological maturity of the industry

Level of technological maturity	Characteristics of the technological process
1 – Low level of technological maturity	Exclusive or predominant use of foreign technologies, business models, and resources (including within the framework of franchising)
2 – Medium level of technological maturity	Partial technology transfer – at least 50% of the technologies used in the production process are domestic
3 – High level of technological maturity	Innovative and project development – exclusive use of domestic technologies in production, including the results of in-house research.

Source: compiled by the authors

A region's industrial technological maturity should be understood as its capacity to achieve technological sovereignty within the national economy, aligning with Russia's current technological policy goals. In this study, technological maturity refers to the industrial sector's ability to develop and adopt new technologies by leveraging the region's socio-economic potential effectively. As Tetlay and John (2009) note, maturity is assessed iteratively throughout a system's lifecycle. In the context of this study, this underscores the need for a mechanism to manage industrial development as a continuous, multistage process with regular evaluation of technological maturity indicators. A «technologically mature» industrial sector is thus characterized not only by its degree of innovation implementation but also by its autonomy from foreign technology providers.

Methods and data

The methodology for assessing a region's industrial technological maturity draws on Glazyev and Sukharev's principles for managing technological development in the Russian economy. These works emphasize, in particular, the need to «counteract import attacks» through technological modernization of the industrial sector (Glazyev & Sukharev, 2024; Sukharev, 2024). As a result, the following levels of industrial technological maturity have been defined (see Table 1).

The selection of indicators to assess the technological maturity of the region's industrial sector was guided by the availability of reliable statistical data from official sources. The assumption was that technological maturity is primarily influenced by regional enterprises' and organizations' innovation, reflected in their R&D activities. Therefore, the following indicators were chosen to capture the key factors of technological maturity:

– number of personnel engaged in R&D (in technical fields of science);

– internal R&D costs (by technical fields of science);

– the number of advanced production technologies developed;

– the number of advanced production technologies used;

– proportion of organizations engaged in innovation;

– the share of innovative products, works, and services in the total volume of completed work;

– export of technologies and technical services (value of contract items, thousand US dollars);

– import of technologies and technical services (value of agreement items, thousand US dollars) (this indicator is inverted, considering its reverse impact on the level of technological maturity).

The data were derived from the publication «Regions of Russia. Socio-economic Indicators. 2023» by the Federal State Statistics Service (items 19 and 22)[6].

The proposed indicators align with the general principles of the National Rating of Scientific and Technological Development for regions. However, unlike the national system, our methodology places emphasis not only on factors that enable technological innovation but also on the assessment of the global competitiveness of research outcomes and the given region's reliance on foreign technologies for its technological development.

The methodology for determining the index of industrial technological maturity is based on

[6] Regions of Russia. Socio-economic indicators. 2023. Official website of the Federal State Statistics Service. Available at: https://rosstat.gov.ru/folder/210/document/13204 (accessed 15.06.2024)

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the international statistical practice of constructing composite indices[7]. To make all data comparable, the min-max normalization method is used (1):

$$X' = \frac{X - X_{min}}{X_{max} - X_{min}}. \quad (1)$$

The indicators are aggregated using the arithmetic mean.

Clearly, the closer the index value is to one, the higher is the level of technological maturity in the region's industry. In this study, equal intervals for the evaluation criteria will be applied. Therefore, an index value above 0.66 will be considered a high level; values between 0.33 and 0.65, a medium level; and values below 0.33 will reflect a low level of technological maturity.

Results

The calculations of the industrial technological maturity index for Russian regions show that that none have reached a high level of technological maturity. Moscow region holds the highest technological maturity with an index value of 0.65. While this region has strong resource potential for industrial innovation, it lags behind in key technological development metrics compared to others, including the share of innovative organizations, the proportion of innovative products and services in total production, and technology exports. Nine regions that have reached the medium level of technological maturity can be considered leaders (see Table 2), as all other regions in the sample show low levels of maturity.

If we look at the results of the top nine regions, we can see that most of them have weaknesses, such as a high dependence on imported technologies and technical services, coupled with low export volumes of their own technologies (see Table 3). At the same time, regions with high internal spending on R&D in technical fields tend to hold leading positions in the production of goods and services. A significant number of regions support innovative production by relying on foreign technologies.

However, even regions that lead in terms of R&D spending and advanced technology creation do not show notable results in exporting technologies and technical services, which could be explained by the fact that their developments are primarily aimed at the domestic market and lack the competitive edge needed to succeed in the international market.

Table 2

Top 9 Russian regions by technological maturity level

Position	Region	Technological Maturity Index
1	Moscow region	0.65
2	Republic of Tatarstan	0.57
3	Nizhny Novgorod region	0.55
4	Sverdlovsk region	0.44
5	Perm region	0.40
6	Rostov region	0.38
7	Republic of Mordovia	0.36
7	Chelyabinsk region	0.36
9	Samara region	0.35

Source: Calculated by the authors based on data from: Regions of Russia. Socio-Economic Indicators. 2023 // Official website of the Federal State Statistics Service.4o mini Available at: https://rosstat.gov.ru/folder/210/document/13204 (accessed 15.06.2024)

As illustrated by Table 3, it can be assumed that the indicators of the region's technological development depend on the number of personnel engaged in R&D and the level of internal spending on R&D. To verify this assumption, we conducted a correlation analysis. The results are shown in Table 4.

As seen from the calculations, the strongest correlation exists between internal spending and the number of personnel engaged in R&D. Significant correlations are also observed between these indicators and the number of advanced technologies developed and used. Regarding the production of innovative goods, works, and services, the most significant correlation is found between this indicator and the share of organizations engaged in innovation. When it comes to the export and import of technologies and technical services, there is a correlation between these indicators and the number of personnel and internal spending on R&D. The correlations with other indicators are insignificant.

In general, it can be concluded that the most significant factors determining the technological

[7] Handbook on Constructing Composite Indicator: Methodology and userguide // Official website of the OECD. Available at: https://www.oecd.org/sdd/42495745.pdf (accessed 15.06.2024)

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Table 3

Strengths and weaknesses of Russian regions with medium technological maturity

Region	Strengths	Weaknesses
Moscow region	R&D personnel Internal spending on R&D Number of advanced technologies developed and used	Low export volume of technologies and technical services
Republic of Tatarstan	Number of advanced technologies developed Proportion of organizations engaged in innovation Share of innovative goods and services	Low export volume of technologies and technical services High import volume of foreign technologies and technical services R&D spending R&D personnel
Nizhny Novgorod region	Export of technologies and technical services R&D spending R&D personnel	Number of advanced technologies developed
Sverdlovsk region	Internal R&D costs Number of advanced technologies developed	Low export volume of technologies and technical services High import volume of foreign technologies and technical services
Perm region	Number of advanced technologies used	Low export volume of technologies and technical services High import volume of foreign technologies and technical services
Rostov region	Share of innovative goods and services	Low export volume of technologies and technical services High import volume of foreign technologies and technical services R&D spending
Republic of Mordovia	Proportion of organizations engaged in innovation Share of innovative goods and services	Low export volume of technologies and technical serviced High import volume of foreign technologies and technical services R&D spending R&D personnel Number of advanced technologies developed and used
Chelyabinsk region	Number of advanced technologies developed and used Proportion of organizations engaged in innovation Share of innovative goods and services	Low export volume of technologies and technical services
Samara region	Number of advanced technologies used Proportion of organizations engaged in innovation Share of innovative goods and services	Low export volume of technologies and technical services High import volume of foreign technologies and services

Source: compiled by the authors

maturity of industry are related to the resource components of innovative development, which requires special attention from regional authorities.

Discussion

Our findings generally align with the previous research evidence that R&D spending, as well as the number of R&D personnel, have a significant impact on the technological development of a region (Drapkin et al., 2024; Naumov & Nikulina, 2023; Rostovskaya & Zolotareva, 2022; Turgel et al., 2020). The comparison with the National Rating of Scientific and Technological Development of the regions of the Russian Federation[8] shows similar results, confirming the reliability of the conclusions drawn. A distinctive feature of our approach is the inclusion of indicators that help determine the extent to which the region's economy depends on imported technologies and technological services. This supports the Russian government's stance on developing the national econ-

[8] National Rating of Scientific and Technological Development of the regions of the Russian Federation. Official website of the Ministry of Education and Science of Russia. Available at: https://minobrnauki.gov.ru/Методология.Национальный%20рейтинг%20НТР.pdf (accessed 15.06.2024)

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Table 4

Results of the correlation analysis of indicators reflecting the region's industrial technological maturity

	R&D personnel	Internal R&D costs	Number of advanced technologies developed	Number of advanced technologies used	Proportion of organizations engaged in innovation	Share of innovative products and services	Export of technologies and technical services	Import of technologies and technical services
R&D personnel	1							
Internal R&D costs	0.980	1						
Number of advanced technologies developed	0.658	0.634	1					
Number of advanced technologies used	0.715	0.701	0.689	1				
Proportion of organizations engaged in innovation	0.322	0.295	0.401	0.425	1			
Share of innovative products and services	0.249	0.236	0.345	0.298	0.653	1		
Export of technologies and technical services	0.404	0.480	0.023	0.206	0.188	0.154	1	
Import of technologies and technical services	0.310	0.321	0.212	0.232	0.052	-0.018	0.152	1

Source: Calculated by the authors

omy through the technological modernization of production, built on domestic innovations.

It is clear that each level of technological maturity requires industrial policies tailored for each region. Moreover, the process of technological development is closely linked to ensuring the financial and economic sustainability of industrial growth, as the introduction of new technologies requires significant investments and is impossible without prior capital accumulation.

Regional policy measures could consider these regions' technological maturity levels and include the following:

– systematic training of highly qualified personnel for industry, including R&D personnel;

– integration of in-house innovations into ongoing industrial processes;

– investments in R&D, based both on in-house developments and the adaptation of foreign technologies to the Russian context

It should be noted that for regions with a low level of industrial technological maturity, it is essential to reduce the level of import dependency in production. This can be achieved by investing in «imitative» import substitution projects that borrow innovations, as well as by launching partnership projects within clusters that include, alongside innovative enterprises and growth hubs, peripheral companies to promote the diffusion of innovation. For regions with higher levels of industrial technological maturity, it is necessary to stimulate investment in domestic R&D, support the innovative development of export-oriented industries, and promote the growth of high-tech business ecosystems.

In general, it can be concluded that incorporating the concept of technological maturity into industrial development strategies helps identify and address barriers to creating «mature» technologies. This approach establishes funding mechanisms while accounting for the challenges associated with industrial development at each maturity level. Regional financial resources should be allocated across various economic sectors through carefully designed partnership agreements, prioritizing technologies at the stage of commercial application. The effectiveness of technological policies is often measured by the speed at which technologies transition from one maturity stage to the next—a process heavily influenced by investment. Therefore, it is critical to differentiate between investments aimed at sustaining older technologies and those dedicated to developing and implementing new ones

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to guide the region's technological growth effectively (Sukharev, 2024). The technological maturity index reflects an industry's readiness to undertake large-scale independent research. A low maturity level implies significant risks for investments in breakthrough technologies, as these may lack immediate demand in the industry. Incorporating the evaluation of technological maturity into regional strategies helps improve priority setting in investments and allocate resources effectively to support innovation.

Conclusion

Our study shows the need to assess a region's technological maturity, reflecting both its own R&D resources and its reliance on foreign technologies and services, when formulating strategies for socio-economic development. The proposed framework is suitable for evaluating industrial technological maturity of a region, thus offering a practical tool to guide decision-making in industrial policy implementation. This approach can be used to monitor key indicators of technological sovereignty, thereby guiding evidence-based investment allocation to strengthen it. The understanding that technological maturity in the industrial sphere is determined not only by the use of modern technologies but also by the level of technological independence in production provides valuable insights.

Undoubtedly, this study has some limitations. The technological maturity index was calculated using specific indicators that reflect the resource capabilities and technological development outcomes of the region's industry. However, to ensure a more comprehensive and accurate assessment, it is necessary to calculate the index for each sector individually, incorporating a broader dataset that captures the intensity of technology use specific to each industry. Nevertheless, this methodology can be refined and adjusted by incorporating additional indicators, depending on the available data for specific industries.

It is generally believed that the more technologically mature is an industry, the more efficient it is. However, this assertion requires further investigation, which defines the direction of our future endeavors.

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Analyzing the relationship between corruption and socio-economic development in Kazakhstan's regions

ABSTRACT

Relevance. Corruption remains a persistent issue in many countries, including Kazakhstan. By exploring the relationship between the socio-economic characteristics of specific regions and corruption, this research can provide a foundation for informed policy-making and targeted anti-corruption efforts and thus help mitigate its negative impact on regional development.

Research Objective. The research aims to assess the impact of corruption on regional socio-economic development in Kazakhstan through the creation and application of a multifactor corruption index.

Data and Methods. The study uses official statistical data on corruption offenses and regional socio-economic indicators, including industrial production, fixed asset investments, household expenditures, unemployment rates, and foreign trade volumes. A multifactor index methodology was employed, using Pearson correlation coefficients to calculate averaged absolute values of sub-indices for each indicator.

Results. The study found strong correlations between corruption and socio-economic indicators in regions like East Kazakhstan, Abay, Akmola, and Kostanay. The economic structure of these regions plays a key role: East Kazakhstan and Akmola, with dominant mining industries, are more vulnerable to corruption due to public contracts and licensing. Kostanay's agricultural sector, central to its economy, is prone to corruption in land allocation, subsidies, and procurement. The economic importance of these sectors amplifies the impact of corruption on development, strengthening the correlation. Conversely, regions with lower index values show weaker correlations in the analysis, likely due to economic diversity, incomplete data, or less effective governance mechanisms.

Conclusions. The regional specificity of the interrelation between corruption and socio-economic development in Kazakhstan necessitates tailored approaches that consider the unique conditions of each region. These findings can be of interest to policymakers and other stakeholders. The proposed methodology allows for a more precise assessment of both hidden and visible corruption risks, highlighting critical areas for implementing effective anti-corruption measures.

KEYWORDS

corruption, regional development, socio-economic indicators, public service, anti-corruption strategies

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Анализ взаимосвязи коррупции и социально-экономического развития регионов Казахстана

АННОТАЦИЯ
Актуальность. Коррупция представляет собой актуальную проблему для многих стран, включая Казахстан. Изучение взаимосвязи между социо-экономическими характеристиками конкретных регионов и коррупцией может помочь создать основу для выработки соответствующей региональной политики и мер по борьбе с коррупцией и тем самым способствовать снижению её негативного воздействия на региональное развитие.
Цель исследования. Целью исследования является изучение влияния коррупции на социально-экономическое развитие регионов Казахстана путем построения и использования многофакторного индекса коррупции.
Данные и методы. Использованы официальные статистические отчеты по коррупционным правонарушениям, а также данные национальной статистики по социально-экономическим показателям развития регионов, включая промышленное производство, инвестиции в основные средства, потребительские расходы домохозяйств, уровень безработицы и объем внешней торговли. Применен метод многофакторного индекса, рассчитанного путем усреднения абсолютных значений отдельных подиндексов для каждого социально-экономического показателя региона с использованием коэффициентов корреляции Пирсона.
Результаты. Установлено, что сильная взаимосвязь между коррупцией и показателями социо-экономического развития, характерна для таких регионов, как Восточно-Казахстанская, Абайская, Акмолинская и Костанайская области. Экономическая структура этих регионов играет ключевую роль: Восточный Казахстан и Акмолинская область, в которых важнейшую роль играет горнодобывающая промышленность, оказались более уязвимыми по отношению к коррупции, из-за государственных контрактов и лицензирования. В Костанае, где превалирует сельское хозяйство, повышается вероятность коррупции при распределении земли, субсидий и госзакупках. Экономическое значение этих отраслей увеличивает влияние коррупции на развитие, что выражается в более сильной корреляции. В регионах с низкими значениями индекса наблюдается слабая взаимосвязь, что может объясняться более дифференцированной экономической структурой, недостатком данных или менее эффективными механизмами управления.
Выводы. Региональная специфика взаимосвязи между коррупцией и развитием в Казахстане обусловливает необходимость адаптированных подходов, учитывающих уникальные условия каждого региона. Применение многофакторного индекса коррупции, адаптированного к региональному анализу, предоставляет новые инсайты и практические рекомендации для политиков и заинтересованных сторон. Такой индекс позволит более точно оценить скрытые и явные риски, связанные с коррупцией, и выявить ключевые точки для применения эффективных антикоррупционных мер.

КЛЮЧЕВЫЕ СЛОВА
коррупция, региональное развитие, социально-экономические показатели, государственная служба, антикоррупционные стратегии

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分析腐败与哈萨克斯坦各地区社会经济发展之间的关系

摘要
现实性：腐败是包括哈萨克斯坦在内的许多国家面临的一个紧迫问题。研究特定地区的社会经济特征与腐败之间的关系有助于为地区反腐败政策和措施提供依据，从而减少腐败对地区发展的负面影响。
研究目标：本研究旨在通过构建和使用多因素腐败指数，研究腐败对哈萨克斯坦各地区社会经济发展的影响。
数据与方法：使用了关于腐败犯罪的官方统计报告，以及地区发展社会经济指标的国家统计数据，包括工业生产、固定资产投资、家庭消费支出、失业率和外贸额。研究方法是多因素指数分析，该指数是利用皮尔逊相关系数计算出的该地区每个社会经济指标的绝对值的平均值。
研究结果：研究发现，腐败与社会经济发展指标之间的强相关性是东哈萨克斯坦州、阿巴伊州、阿克莫拉州和科斯塔奈州等地区的共同特点。这些地区的经济结构都各有不同：东哈萨克斯坦州和阿克莫拉州的采矿业发达，由于国家合同和许可证的发放，这些地区更容易受到腐败的影响。在农业占主导地位的科斯塔奈州，在土地分配、补贴和公共采购方面发生腐败的可能性更大。这些部门的经济重要性增加了腐败的可能性。指数值较低的地区相关性较弱，这可能是由于经济结构更加分化、缺乏数据或治理机制不够有效。
结论：哈萨克斯坦的腐败与发展之间的关系具有地区特殊性，因此有必要针对各地区定制独特方法。区域分析的多因素腐败指数为政策制定者和利益相关者提供了新的见解和实用建议。这一指数将有助于更准确地评估与腐败有关的潜在和显性风险，并确定采取有效反腐败措施的关键点。

关键词
腐败、地区发展、社会经济指标、公共服务、反腐败战略

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Introduction

This study examines how corruption relates to socio-economic development across Kazakhstan's regions. The objective is to identify regional disparities, understand the influence of corruption on socio-economic outcomes, and propose tailored anti-corruption strategies. Given the geographical and economic diversity of Kazakhstan, the study recognizes that factors such as regional economic structure, natural resources, and local governance contribute to differences in corruption levels and development outcomes. To analyze this relationship, the study uses a multifactor index method, which calculates the average of individual sub-indices for each socio-economic indicator, employing Pearson correlation coefficients to identify key patterns and correlations.

Corruption, as a concept, has evolved over time, acquiring different historical and cultural meanings (Friedrich, 2017; Ladikos, 2002). It is often viewed as a threat to prosperity, democracy, and human well-being (Rothstein & Varraich, 2017). Corruption manifests differently across regions, significantly affecting socio-economic structures. This regional variation requires a nuanced approach, taking into account factors such as natural resources, culture, and economic activity (Panasyuk et al., 2014). These interactions can result in varied impacts on economic growth, social justice, and public trust.

Corruption is a global issue that profoundly affects economic and regional development. Defined as the misuse of power for personal gain, corruption undermines governance, economic stability, and societal welfare (Nichols, 2017). While some studies suggest that corruption may speed up certain economic processes by bypassing bureaucratic delays, most research indicates that it generally harms economic prosperity, distorts public spending, and worsens regional inequalities (Khan, 2018; Sari & Rahardjo, 2019a; Uribe et al., 2019; Yusof et al., 2023).

Corruption also negatively impacts human capital management in public services. It dis-

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torts recruitment and professional development systems, reducing the effectiveness of human resource management (Sundell, 2014). Corrupt practices often favor individuals with personal connections rather than competence, lowering professionalism and eroding public trust in government institutions (Besley & Persson, 2010). Moreover, corruption diminishes employees' motivation and commitment to ethical standards, leading to inefficiency and declining service quality (Dahlström et al., 2012). Over time, this can weaken the civil service and hinder national socio-economic development.

Corruption significantly influences national economic growth by affecting key indicators such as GDP, national debt, and foreign direct investment (Yusof et al., 2023). It leads to inefficiencies that undermine financial benefits, exacerbating regional inequalities. The effects of corruption include negative impacts on GDP, investment, public spending, capital flows, and foreign aid, making it harder to achieve sustainable growth (Khan, 2018). Additionally, corruption increases income inequality and poverty (Uribe et al., 2019), distorting social spending and deepening regional development gaps. It also misallocates public budgets, destabilizing economic growth, GDP per capita, investment, international trade, and price stability (Sari & Rahardjo, 2019b).

To combat corruption, it is essential to understand its causes. Financial and administrative corruption are major obstacles to economic growth (Moniri et al., 2013). Key factors include the clarity of financial laws, transparency in executive policies, the effectiveness of accounting systems, and the dynamic relationships between financial and regulatory organizations. Addressing these elements is vital for developing effective anti-corruption strategies.

Empirical evidence supports the link between corruption and economic development, showing that corruption negatively affects key indicators such as Gross Domestic Product (GDP), GDP growth rate, and Foreign Direct Investment (FDI). Singh (2022) found that corruption has a detrimental impact on economic performance, reinforcing the negative correlation between corruption and economic development.

Regional disparities in corruption and economic development are shaped by various factors. Economic development and the evolution of social institutions are crucial in reducing corruption (Bajada & Shashnov, 2019). As countries progress, their social institutions become better equipped to combat corruption, enhancing social and economic well-being. However, corruption's impact varies across regions. Sinha (2022) highlights that factors such as economic growth, public sector size, and human development are key determinants of corruption, with significant regional variations. For example, literacy rates may play a crucial role in some regions but not in others. These findings underscore the need for region-specific approaches to understanding and addressing corruption, rather than relying solely on national-level analyses.

Given this complexity, it is crucial to examine the specific regional dynamics of corruption to fully understand its implications. Regions in Kazakhstan vary significantly in socio-economic development, necessitating an analysis of how corruption uniquely impacts each one. This study addresses this gap by exploring the relationship between corruption and regional development in Kazakhstan.

The article is structured as follows: The introduction outlines the relevance of the study and its objectives. The section on theoretical framework discusses key institutional theories of corruption and their relevance to regional socio-economic development. The methodology section describes the creation and application of a multifactor corruption index, incorporating official statistical data on socio-economic indicators and corruption offenses. Subsequent sections analyze the results, focusing on the interplay between corruption and regional development, and provide a discussion on the implications of these findings for policymakers and stakeholders.

Theoretical framework

This section examines the relationship between corruption and regional development by grouping sources into thematic categories based on their focus: corruption's socio-economic impacts, institutional theories, international anti-corruption efforts, advanced methodologies, and regional differences. This structure allows for a comprehensive exploration of the topic while highlighting the diverse perspectives and approaches in the existing literature. By organizing the sources in this way, the analysis emphasizes the multifaceted nature of corruption and its regional variations, providing a clear foundation for understanding its implications in Kazakhstan.

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The relationship between corruption and regional development has been extensively explored, with studies emphasizing its substantial impact on various socio-economic factors. Corruption, often viewed as a single issue, manifests differently across regions, leading to unequal effects on their socio-economic structures. This regional variability calls for a more nuanced approach, shifting from national averages to detailed regional analysis.

Corruption and its impact on socio-economic development

Corruption arises from a complex interplay of economic, political, and cultural factors. Del Monte and Papagni (2007) and Corrado and Rossetti (2018) emphasize that in Italy, economic factors such as government consumption and development levels, alongside political and cultural influences like party concentration and the presence of voluntary organizations, significantly affect corruption levels. Corrado and Rossetti (2018) further highlight the importance of local public spending size and composition, noting that regions with higher social capital tend to experience lower corruption rates. Moreover, regions with historically weaker anti-corruption efforts may become trapped in a persistent cycle of elevated corruption.

Heywood and Rose (2014) estimate the financial cost of corruption at more than 5% of global GDP. Despite worldwide efforts to combat corruption, it remains pervasive. Heywood and Rose (2014) review various approaches to measuring corruption, focusing on both perception-based and non-perception methods. A significant gap exists between the conceptualization of corruption and its measurement, creating tension between policymakers seeking practical solutions and researchers highlighting corruption's complexity.

Institutional theories of corruption shift the focus from individual misconduct to systemic issues within organizations. Thompson (2018) argues that institutional corruption can benefit an institution while undermining its intended purpose. This perspective has been applied across sectors such as Congress, regulatory agencies, and private companies. Some scholars suggest that institutional corruption is best understood through a fiduciary lens, focusing on the trust and obligations that institutions owe to the public (Newhouse et al., 2013). Other frameworks, including those based on institutional logics and resources, explore how organizational structures and cultural practices contribute to corrupt behavior (Pillay, 2014; Pillay & Kluvers, 2014).

Research has applied institutional theory to public sector organizations in various cultural contexts, including studies by Sudibyo & Jianfu (2015), which underscore the importance of considering local cultural and institutional factors when analyzing corruption. These factors can significantly influence the effectiveness of anti-corruption strategies. Alternative perspectives view institutional corruption as an organizational design problem, where the structure and processes within institutions create opportunities for corrupt practices (Oliveira, 2014). Historical institutionalism further emphasizes the role of power in maintaining corrupt systems, arguing that corrupt practices are often entrenched within institutional frameworks (Hellmann, 2015). These diverse approaches collectively aim to deepen the understanding of systemic corruption in different institutional settings, offering insights into potential reforms to mitigate its impact on both institutional operations and broader societal structures.

International organizations play a key role in the global fight against corruption, despite facing significant challenges. Major players such as the United Nations, World Bank, IMF, and Transparency International have been instrumental in promoting anti-corruption discourse and practices (Snyman, 2022). These organizations employ a range of strategies, including accountability mechanisms, transparency initiatives, risk assessments, investigations, and sanctions (Bowra et al., 2022). In particular, hybrid anti-corruption agencies backed by the UN and Organization of American States (OAS) have been established in regions such as Central and South America, offering innovative approaches to combating corruption (Zamudio-González, 2021).

However, the effectiveness of these international anti-corruption initiatives is often limited by a lack of understanding of local contexts and norms (Snyman, 2022). To enhance their impact, international actors can serve as information providers, facilitators, and project sponsors, while also collaborating closely with civil society organizations (Rose-Ackerman, 2011; Yaxshibayevna, 2021). Such collaboration is crucial to ensuring that anti-corruption strategies are not only imple-

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mented but also adapted to the specific socio-cultural environments of the regions they target.

Recent advancements in research have highlighted the potential of innovative methodologies for measuring and combating corruption, particularly through the integration of big data and machine learning technologies. For instance, machine learning algorithms have been successfully used to predict corruption levels across different countries (Lima & Delen, 2020) and classify corruption-related content in media outlets (Artemova et al., 2022). Additionally, the development of news flow indices has improved the monitoring of corruption and anti-corruption activities (Hlatshwayo et al., 2018), while unsupervised learning techniques have proven effective in detecting corruption reports shared on social media platforms (Li et al., 2019). These approaches highlight the transformative potential of advanced analytics in enhancing both the accuracy of corruption measurement and the effectiveness of mitigation strategies (Yatsyna & Kudinov, 2023).

Despite their potential, the application of advanced methods in combating corruption comes with significant challenges, particularly around data accessibility, quality, and interpretability (Johnston, 2017). To overcome these obstacles, innovative solutions such as federated learning frameworks, open data catalogs, and blockchain technologies can help address issues related to data fragmentation and privacy concerns (Denny et al., 2021). However, the implementation of digital anti-corruption mechanisms still faces limitations, including the need for substantial infrastructure and the risk of overlooking context-specific factors that are essential for understanding and effectively tackling corruption (Nurkey et al., 2022).

Overall, these studies emphasize the growing significance of advanced analytics in the ongoing global efforts to combat corruption. As these technologies continue to evolve, they hold considerable potential to enhance the precision and impact of anti-corruption initiatives, offering more nuanced and actionable insights into the complex dynamics of corruption.

The relationship between corruption and socio-economic indicators

The negative impact of corruption on economic growth is extensively documented. Lambsdorff (2003) quantified this impact, showing that a one-point increase in corruption (from 10 to 0) leads to a 4% decline in GDP productivity and a 0.5% reduction in net annual capital inflows. The study highlights that corruption undermines bureaucratic quality, which in turn impedes productivity. Furthermore, the lack of robust law and order traditions exacerbates the decline in capital inflows. Lambsdorff suggests prioritizing public sector and legal reforms to enhance productivity and attract foreign investment, respectively.

Further exploration by Densumite (2023) examined the relationship between corruption and economic growth in twelve countries over a period of 26 years. The study utilized various econometric methods, including panel unit root tests, panel cointegration tests, Dynamic Ordinary Least Squares (DOLS) estimation, and Vector Error Correction Model (VECM) methodology. The results indicated that corruption has a negative effect on economic growth, with a 1% increase in transparency leading to a 0.20% increase in GDP growth in the long run. This comprehensive approach provides robust evidence of the detrimental impact of corruption on economic performance and highlights the importance of effective anti-corruption policies for sustained economic growth.

Sriyalatha (2019) investigated the impact of corruption on economic growth in South Asian countries, using macro-level panel data from four countries over the period 2002-2016, and found that a one-unit increase in corruption retards economic growth by roughly 0.0282 percent. Additionally, the study highlighted the positive effects of physical and human capital on economic growth and emphasized the need for robust anti-corruption measures to enhance economic performance.

Gillanders (2014) explored the relationship between corruption and infrastructure at both the national and regional levels using data from the World Bank's Enterprise Surveys. It found a statistically significant link between corruption and the quality of transportation and electricity infrastructure, with countries experiencing higher levels of corruption generally having worse infrastructure. This pattern holds true at the regional level, where significant variations in corruption within countries also impact infrastructure quality. Similarly, Coetzee (2014) demonstrated that corruption negatively affects infrastructure and development, particularly harming vulnerable

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populations. Corruption disrupts the establishment of a healthy marketplace, encourages mismanagement in public institutions, and distorts development, with the most disadvantaged groups bearing the brunt of its negative effects, making it a major governance and development challenge.

Several studies have emphasized the broader economic implications of corruption. Mauro (1995) found that corruption reduces investment, thereby impeding economic growth. Gupta et al. (2002) provided evidence that corruption exacerbates income inequality and poverty by disproportionately allocating resources to the wealthy and well-connected, further marginalizing the poor.

Regional differences in the impact of corruption

Eshun & Baah (2020) conducted a study in Africa, revealing that corruption significantly exacerbates poverty by diverting resources from public services to private gains. Their findings indicated that effective anti-corruption measures could lead to substantial improvements in poverty alleviation efforts. Urbina (2020) highlighted the economic consequences of corruption, noting that it distorts market mechanisms, increases transaction costs, and fosters an environment of uncertainty and inefficiency. Malaj & Firza (2023) started the Western Balkan countries and demonstrated that corruption inhibits foreign direct investment (FDI) by creating an unpredictable business environment, thereby reducing economic growth potential. This is echoed by Aguirre-Unceta (2024), who analyzed Kazakhstan's extractive resources sector and found that corruption significantly deters inclusive development by concentrating wealth and opportunities among a small elite, thereby widening socio-economic disparities

Fiorino et al. (2012) noted that less developed regions are more susceptible to corruption due to weaker institutional frameworks and higher levels of poverty. Yang et al. (2017) explored the negative impacts of high levels of corruption on operational efficiency in companies, illustrating the complex relationship between corruption and economic performance. Regional disparities in corruption levels were highlighted by Prihatmanto et al. (2023), who examined corruption in Indonesian villages and found significant regional variations in the incidence and detection of corruption cases. The study underscores the importance of implementing regulations that mandate regular audits and detection policies tailored to specific attributes, such as region, development level, perpetrator profiles, and trends in fraudulent schemes.

In regions with high corruption levels, there are greater challenges in attracting and retaining qualified personnel in public service, which distorts meritocratic principles. Rather than selection based on professional qualities and competencies, personal connections and corruption schemes often dominate, leading to the appointment of less qualified but loyal candidates. This negatively impacts public service effectiveness and erodes citizen trust in authorities. Differences in corruption levels between regions also result in disparities in access to resources for developing human capital (Treisman, 2000). In regions with lower corruption levels, civil service training, advanced education, and professional development programs are implemented more effectively, improving management quality and services offered to the population (Kaufmann et al., 2009). In such regions, the likelihood of adopting modern technologies and human resource management methods is higher, allowing the civil service to better adapt to societal needs. Conversely, in regions with high corruption levels, there is a shortage of resources for human capital development, and existing programs are often carried out superficially, failing to meet objectives. Corruption schemes in the allocation of budget funds lead to poor-quality educational and training programs, hindering civil servants' professional growth and worsening local governance. This exacerbates the socio-economic development gap between regions and impedes the achievement of national Sustainable Development Goals (Fisman & Gatti, 2002).

Thus, regional differences in corruption levels significantly affect the management of human capital in the civil service. To mitigate the negative impact of corruption on human capital development, it is essential to develop differentiated strategies that consider regional peculiarities and strengthen control over the implementation of professional development programs. This would create more equitable conditions across regions and improve public service efficiency at the national level.

Prorokov (2015) emphasized the need for combining strict government control with active civil society involvement in anti-corruption

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efforts. This view is supported by Nazarychev & Sigurova (2022), who contributed to understanding regional corruption by presenting a classification of indicators for anti-corruption monitoring in Russia. Their methodology includes multifactorial analysis, incorporating criminological, social, and political indicators to measure regional corruption potential and risks, highlighting the importance of a transparent system for assessing and measuring regional corruption levels. Sidorenko et al. (2020) discussed the importance of preventing regional corruption in Russia, presenting a comprehensive methodology for analyzing and forecasting corruption trends. This approach helped identify systemic dependencies between social indicators and corruption levels, providing a foundation for developing effective anti-corruption strategies.

Corruption in Kazakhstan

There is a considerable body of research that has explored the impact of corruption on regional development in Kazakhstan. Abuova (2020) highlights the negative effects of corruption on economic growth and the rule of law, emphasizing that corruption undermines both public administration and legal institutions. The study notes that corruption hampers economic growth and weakens the rule of law, which further exacerbates the country's developmental challenges. Building on these findings, Mamitova et al. (2016) focus on the deceleration of economic and social institutions in Kazakhstan due to corruption, suggesting that it breeds distrust in authorities and contributes to social unrest. The research also examines countermeasures, emphasizing the need for public involvement and legislative reform. Moreover, the study identifies new forms of corruption, such as the abuse of influence and illicit enrichment, recommending their criminalization in Kazakhstani law.

Expanding on this issue, Zhanbozova et al. (2023) investigate the relationship between corruption and poverty in Kazakhstan, finding that corruption has a statistically significant impact on poverty levels, though the effect is less pronounced when additional variables are considered. The study compares Kazakhstan's situation with countries like Argentina, Germany, and Denmark, highlighting both commonalities and distinctions. The authors suggest that less obvious mechanisms might mediate the relationship between corruption and poverty in Kazakhstan, pointing to the need for further research employing nonlinear models and more precise variables. Similarly, Zharlygassinov et al. (2023) examine the impact of corruption on the Human Development Index (HDI) and its components. Their analysis reveals that corruption negatively affects key social sectors such as healthcare and education, which diminishes the standard of living and fosters the shadow economy. The study underscores the correlation between corruption and lower HDI scores, stressing the importance of effective anti-corruption measures to improve human development outcomes. Mukhamediyev et al. (2023) further argue that authorities must closely monitor regional socio-economic indicators and implement measures to prevent significant declines, particularly regarding poverty levels.

In a broader context, Panzabekova et al. (2021) provide a comprehensive assessment of Kazakhstan's institutional environment in relation to corruption. The study examines both formal and informal institutions as determinants of illegal behavior, using comparative indicators developed by international organizations and Hofstede's "indices of cultural dimensions." By comparing Kazakhstan's institutional environment over time and with other countries, the study highlights the unique characteristics of Kazakhstan's corruption landscape. The authors suggest that these insights can inform the development of anti-corruption programs and policies. Additionally, the study emphasizes the need for further research to explore the constituent components of the indices used and the strength of the relationship between corruption and other social institutions.

Despite these valuable studies, there remains a significant gap in the literature regarding the regional characteristics of corruption in Kazakhstan. Being the ninth largest country in the world by land area, Kazakhstan has substantial regional diversity in terms of economy, society, and culture. Given this diversity, it is essential to understand how corruption manifests differently across these regions. The vast territorial expanse and regional disparities suggest that corruption may not be uniform throughout the country. However, specific studies on regional variations of corruption within Kazakhstan are notably lacking. Addressing this gap is crucial for developing targeted and effective anti-corruption strategies that account for the unique dynamics of each region.

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Overall, while research literature underscores the pervasive and multifaceted impacts of corruption on regional development, there is a clear need for more region-specific studies, particularly in Kazakhstan. Such research is necessary to better understand the region-specific dynamics of corruption and to formulate more targeted and effective policy interventions.

Method and Data

To systematically analyze the multidimensional relationship between corruption and regional development, this study employs a robust quantitative methodology. This section describes the data sources, variable selection, and econometric approaches used to generate and analyze the multifactor index. The goal of using a comprehensive dataset and advanced statistical methods is to create a nuanced view of how corruption impacts regional development dynamics.

Data Sources and Variable Selection

The primary data for this study are sourced from official statistical reports and databases. Corruption prevalence is measured by the number of registered offences under Chapter 15 of Report No. 1-M, "On Registered Criminal Offenses." These data are obtained from the official legal statistics portal of Kazakhstan, implemented in accordance with Paragraph 12-5, Article 6 of the Law of the Republic of Kazakhstan dated December 22, 2003, No. 510, "On State Legal Statistics and Special Records." The portal, informed by the Unified Pre-Trial Investigation Register, aims to provide accessible crime statistics to the public, thereby promoting transparency and enabling the reuse of open data by researchers, public organizations, and information system developers.

To assess the impact of corruption on regional development, the study incorporates various socio-economic indicators, including industrial production, investment in fixed assets, household expenditures, unemployment rates, and foreign trade turnover. The selection of these indicators provides a comprehensive framework to evaluate the multifaceted implications of corruption on regional socio-economic dynamics. The analysis focuses on the correlation between the absolute values of these socio-economic indicators, such as the number of corruption crimes and industrial production. While absolute values are the focus of this analysis, future research could explore growth rates to capture dynamic changes over time.

The indicators, including unemployment rates and industrial production, were selected for their relevance to regional economic development. While some connections, like those between corruption and unemployment, may not seem obvious, previous research suggests that corruption influences labor market dynamics through resource misallocation and governance inefficiencies.

The study uses annual data from 2018 to 2022 to ensure consistency and to examine recent trends in the relationship between corruption and socio-economic development across Kazakhstan's regions. Data on registered corruption offenses[1] are sourced from the official legal statistics portal, qamqor.gov.kz, which draws from the Unified Pre-Trial Investigation Register. Socio-economic indicators, including industrial production[2], investments in fixed assets[3], household cash expenditures[4], unemployment rates[5], and foreign trade turnover[6], are sourced from the Bureau of National Statistics, under the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan. These diverse data sources collectively enable a robust analysis of the impact of corruption on regional socio-economic indicators, ensuring the inclusion of reliable and comprehensive datasets.

This study focuses on the number of registered offenses under Chapter 15 ('Corruption and other criminal offenses against public service and administration') as the primary corruption indicator. Independent variables include socio-economic indicators such as industrial production, investment in fixed assets, household expenditures, unemployment rates, and foreign trade turnover, selected for their relevance to regional development and potential vulnerability to corruption. The use of registered offenses as a corruption measure is driven by data availability and

[1] Retrieved from https://qamqor.gov.kz/crimestat/statistics

[2] Retrieved from https://old.stat.gov.kz/official/industry/151/statistic/7

[3] Retrieved from https://stat.gov.kz/ru/industries/business-statistics/stat-invest/

[4] Retrieved from https://old.stat.gov.kz/official/industry/64/statistic/7

[5] Retrieved from https://old.stat.gov.kz/official/industry/25/statistic/7

[6] Retrieved from https://old.stat.gov.kz/official/industry/31/statistic/8

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reliability, as corruption research often faces challenges due to the secretive nature of corrupt activities and limitations in perception-based measures (Serra et al., 2012). Data from the qamqor.gov.kz portal (2018-2022) provide consistent and reliable information on corruption within public service and administration, which is more readily accessible than data on other sectors like non-governmental organizations or corporations.

Previous research underscores the complexity of studying corruption and its impact on economic outcomes, noting that openness and data availability play crucial roles in shaping our understanding of these issues (Lambsdorff, 2005; Neeman et al., 2003). While open data initiatives and freedom of information laws have shown promise in enhancing transparency and combating corruption, their effectiveness is influenced by various factors, such as media freedom, internet access, and the quality of available data (Hulstijn et al., 2017; Žuffová, 2020). Despite these advancements, challenges like information asymmetry and data quality persist, making it difficult to capture the full scope of corruption (Darusalam et al., 2019).

Although official statistics offer a reliable measure of registered corruption crimes, it is recognized that these figures may not fully encompass the broader and more nuanced manifestations of corruption. Future research could benefit from the inclusion of supplementary data sources, such as surveys, media reports, and social media content, to develop a more comprehensive and multidimensional perspective on corruption activities.

Subindices: calculation and use

To assess the relationship between corruption and various socio-economic indicators across Kazakhstan's regions, this study employs subindices for key areas such as industrial production, investment in fixed assets, household expenditures, unemployment rates, and foreign trade turnover. Each subindex is calculated using the Pearson correlation coefficient, which measures the relationship between the number of corruption offences and the respective socio-economic indicators for a given region. The use of subindices allows for a more detailed analysis, highlighting the specific aspects of regional development that interact most with corruption.

The socio-economic variables used in the analysis are first normalized to ensure comparability across regions and different scales. For example, while industrial production is measured in billion tenge, unemployment is represented as a percentage. Normalization ensures that each variable is on a common scale, allowing for meaningful comparisons between them. The subindices are interpreted based on the strength and direction of the correlation. Values close to -1 or 1 indicate a strong relationship, either negative or positive, between corruption and the given indicator. For instance, a negative subindex for industrial production indicates that higher levels of corruption are associated with lower industrial output in that region. Conversely, values close to 0 suggest a weak or negligible relationship between corruption and the socio-economic indicator. The subindices are then aggregated into an integrated index, which provides an overall measure of the corruption potential in each region. This integrated index is calculated by averaging the absolute values of the subindices. The use of absolute values ensures that correlations of differing signs do not cancel each other out, thereby providing a more accurate reflection of the magnitudes of interaction of corruption on regional development. This approach allows for the identification of regions where corruption has a particularly strong effect on multiple socio-economic indicators and helps policymakers target their anti-corruption efforts accordingly.

Analytical approach

As emphasized by Hawken & Munck (2006), improving the quality of corruption data is crucial for accurate analysis and the effective design and evaluation of anti-corruption initiatives. The selection of variables in this study was guided by both theoretical considerations and prior empirical evidence. The number of registered corruption offenses directly measures corruption prevalence and is key to understanding its impact on regional development. Socio-economic indicators were chosen for their relevance to regional development and their potential vulnerability to corruption.

The volume of industrial production reflects the economic output and industrial activity of a region, which can be significantly influenced by corruption through resource misallocation and adverse effects on the business environment. Investment in fixed capital, which indicates economic growth potential and infrastructure de-

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velopment, is similarly affected by corruption, particularly in public procurement and project execution. Household monetary expenditures provide insights into the standard of living and well-being of residents, as corruption can divert resources from public services and negatively affect consumption. The unemployment rate, as a vital socio-economic indicator, can be impacted by corruption through the mismanagement of employment policies and labor market inefficiencies. Finally, foreign trade turnover highlights the level of economic integration and trade activity in a region, which may be affected by corruption through the creation of illicit barriers and other illicit practices.

The analysis involves calculating the Pearson correlation coefficient for each socio-economic indicator to determine the strength and direction of the relationship between corruption crimes and regional development. The Pearson correlation coefficient was employed to quantify these linear relationships due to its simplicity and extensive application in similar empirical studies. However, it is acknowledged that Pearson's correlation assumes a linear association between variables, which may not always hold true in complex socio-economic phenomena. Consequently, future research could benefit from utilizing alternative correlation measures or regression models that account for potential non-linear dynamics. Since the relationship between corruption and socio-economic development indicators is well established, no additional checks were carried out.

Absolute values (i.e. raw levels) were used for the calculations rather than, for example, growth rates for a reason. By using raw levels, the analysis reflects the current burden that corruption imposes on regions, rather than capturing only the trend over time. This perspective is particularly useful for understanding the present-day economic environment and the scale of corruption's direct interaction with the variables.

To assess the relationship between corruption and socio-economic development, subindices were calculated for each indicator by calculating the Pearson correlation coefficients. These subindices were then aggregated into an integrated index by taking the arithmetic mean of their absolute values, ensuring that positive and negative correlations do not cancel each other out. The resulting integrated index provides an overall measure of the corruption potential in each region, offering a comprehensive understanding of how well corruption is embedded into regional development.

The formula for calculating the integral index is as follows:

$$I = \frac{\sum_{i=1}^{n} |x_i|}{n}, \quad (1)$$

where I is the integral index, x_i is a subindex, n is the number of subindices.

Adaptation to the context of Kazakhstan

The methodology was adapted to fit the unique characteristics of Kazakhstan's economy and available data. Estimating corruption risks through the number of officials and the likelihood of punishment for corruption violations was not possible due to the lack of publicly accessible data. To address this, the variables used to assess corruption potential were expanded, incorporating additional indicators from other sources (Senchagov & Mityakov, 2016). Unlike Sidorenko's work, which was cited in the theoretical section of this paper, the study of Senchagov and Mityakov (2016) focuses solely on assessing corruption potential, excluding risk assessment.

The methodology of this study was adjusted to account for regional economic disparities, governance structures, and socio-cultural factors specific to Kazakhstan, ensuring that the index reflects the local context and provides a more accurate assessment of corruption and its impacts.

The study faced several challenges, including limited access to certain types of data and potential biases in self-reported measures of corruption. Additionally, the dynamic nature of corruption and regional development means that the results may be influenced by temporal changes and external factors not captured in the dataset. Despite these challenges, the methodology's comprehensive nature and the robustness of the data sources ensure that the findings are both reliable and relevant. The dynamic and evolving nature of corruption necessitates continuous monitoring and updates to the index to reflect current trends and changes in the socio-economic environment.

Results

The data from six regions had to be paired due to the new administrative division of Kazakhstan, which was implemented in 2022. Since at least five

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observations are required to calculate correlation coefficients, these regions are marked with a "+" sign in the tables, and conclusions are drawn collectively for them.

The results of the calculations of the subindices, specifically the correlation coefficients between the number of corruption crimes and the target variables, are detailed below. First, the industrial potential subindex was calculated (Table 2). In four regions—East Kazakhstan, Abay, Kostanay, and Akmola—a strong inverse relationship was observed, indicating that a decrease in the number of corruption crimes is significantly associated with an increase in industrial production. Additionally, a moderate inverse relationship was noted in seven other regions, including the cities of Almaty and Astana. In contrast, no significant relationship was found between these indicators in the remaining regions.

Table 2

Subindex of production potential

Regions and cities of republican significance	Correlation coefficient (industrial production)
East Kazakhstan + Abay regions	–0.95
Kostanay region	–0.93
Akmola region	–0.92
Karaganda + Ulytau regions	–0.67
West Kazakhstan region	–0.66
Zhambyl region	–0.59
Pavlodar region	–0.55
Almaty	–0.52
Astana	–0.48
Aktobe region	0.33
Kyzylorda region	0.23
Atyrau region	–0.16
Shymkent	0.12
Turkestan region	–0.12
North Kazakhstan region	–0.12
Mangystau region	0.05
Almaty + Zhetysu regions	0.02

Note: Color coding: green – strong relationship, yellow – indirect relationship, red – weak relationship.

Source: compiled by the authors

Subsequently, the investment potential subindex was calculated, representing the correlation coefficient between the number of criminal offenses and the volume of investments in fixed assets (Table 3). Similar to the previous subindex, a strong inverse relationship was identified for the same four regions. Additionally, a strong direct correlation was observed for Shymkent, a city of republican significance. This latter finding is counterintuitive, as it suggests that a decrease in the number of corruption crimes is associated with a decrease in the volume of investment in fixed capital, warranting further investigation. Moreover, a moderate inverse relationship was found for six other regions.

Table 3

Subindex of investment potential

Regions and cities of republican significance	Correlation coefficient (investment in fixed capital)
Akmola region	–0.96
East Kazakhstan + Abay regions	–0.95
Kostanay region	–0.89
Shymkent	0.83
Turkestan region	–0.69
Mangystau region	–0.64
Karaganda + Ulytau regions	–0.55
Almaty	–0.54
Pavlodar region	–0.47
Zhambyl region	–0.43
Atyrau region	0.3
West Kazakhstan region	0.26
Kyzylorda region	0.15
Aktobe region	–0.09
Astana	–0.04
Almaty + Zhetysu regions	0.04
North Kazakhstan region	0

Note: Color coding: green – strong relationship, yellow – indirect relationship, red – weak relationship.

Source: compiled by the authors

Calculations of the consumer potential subindex, which analyzes the correlation between corruption crimes and per capita monetary expenditures, revealed a strong connection in several regions (Table 4). In six regions, a strong inverse relationship was found, indicating that a decrease in corruption crimes is linked to an increase in consumer spending. In contrast, Shymkent showed a direct relationship. Additionally, five other regions demonstrated a moderate inverse relationship.

In the unemployment subindex, only three regions show a strong inverse correlation, meaning that a reduction in corruption crimes is associat-

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ed with higher unemployment. A similar trend is seen in regions with moderate correlation, except for Almaty, where a decrease in corruption is linked to a drop in unemployment (Table 5).

Table 4

Subindex of consumer potential

Regions and cities of republican significance	Correlation coefficient (monetary expenditures per capita)
Kostanay region	–0.9
Akmola region	–0.9
East Kazakhstan + Abay regions	–0.89
Kyzylorda region	–0.76
Shymkent	0.74
Karaganda + Ulytau regions	–0.7
West-Kazakhstan region	–0.66
Mangistau region	–0.66
Zhambyl region	–0.51
Almaty	–0.48
Atyrau region	–0.44
Astana	–0.38
Pavlodar region	–0.34
Turkestan region	–0.19
North Kazakhstan region	–0.1
Aktobe region	–0.04
Almaty + Zhetysu regions	0.03

Note: Color coding: green – strong relationship, yellow – indirect relationship, red – weak relationship.

Source: compiled by the authors

Table 5

Subindex of unemployment

Regions and cities of republican significance	Correlation coefficient (unemployment rate)
Kyzylorda region	–0.85
East Kazakhstan + Abay regions	–0.8
Aktobe region	–0.68
Mangistau region	–0.68
Akmola region	–0.54
Kostanay region	–0.49
Almaty	0.44
North Kazakhstan region	–0.38
Almaty + Zhetysu regions	0.35
Zhambyl region	–0.3
Turkestan region	–0.25
Pavlodar region	–0.23
Shymkent	0.14
Atyrau region	0.2
West-Kazakhstan region	0.08
Astana	0.06
Karaganda + Ulytau regions	0.04

Note: Color coding: green – strong relationship, yellow – indirect relationship, red – weak relationship.

Source: compiled by the authors

The subindex of trade potential shows a significant number of strong correlations: for six regions, the correlation is inverse, meaning that a decrease in corruption is associated with an increase in foreign trade turnover. However, the situation is different for the city of Shymkent (Table 6). Additionally, eight more regions show moderate correlations, with three of them exhibiting direct rather than inverse relationships. The interaction between foreign trade and corruption is likely more complex and multi-faceted than that of other indicators, suggesting the need for individual or cluster-based analysis of each region.

Table 6

Subindex of trade potential

Regions and cities of republican significance	Coefficient correlations (foreign trade turnover)
Kostanay region	–0.95
Akmola region	–0.95
East Kazakhstan + Abay regions	–0.89
Zhambyl region	–0.89
Shymkent	0.85
Pavlodar region	–0.74
Aktobe region	0.68
Almaty	–0.63
Karaganda + Ulytau regions	–0.53
Astana	–0.44
West-Kazakhstan region	–0.43
Mangistau region	0.43
Kyzylorda region	0.42
Almaty + Zhetysu regions	–0.35
Atyrau region	0.28
North Kazakhstan region	–0.19
Turkestan region	–0.12

Note: Color coding: green – strong relationship, yellow – indirect relationship, red – weak relationship.

Source: compiled by the authors

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Combining the subindices into an integral index of corruption potential allows for assessing the overall relationship between corruption and regional development. While this index differs from correlation coefficients in interpretation, it offers insights into the intensity and extent of the connection between corruption crimes and regional development indicators (Table 7). Regions were ranked in descending order of the index value (by modules) and then grouped to ensure that regions with similar index values were placed together.

Table 7

Integral index of corruption potential

Regions and cities of republican significance	Integral index of corruption potential
East Kazakhstan + Abay regions	0.9
Akmola region	0.85
Kostanay region	0.83
Zhambyl region	0.54
Shymkent	0.54
Almaty	0.52
Karaganda + Ulytau regions	0.5
Mangistau region	0.49
Kyzylorda region	0.48
Pavlodar region	0.47
West-Kazakhstan region	0.42
Aktobe region	0.36
Astana	0.28
Atyrau region	0.28
Turkestan region	0.28
Almaty + Zhetysu regions	0.16

Note: Color coding: green – strong relationship, yellow – indirect relationship, red – weak relationship.

Source: compiled by the authors

The findings from our analysis of the corruption index reveal significant regional disparities in Kazakhstan, particularly in the relationship between corruption and regional development indicators. Regions such as East Kazakhstan, Abay, Akmola, and Kostanay show a strong correlation between corruption and development, with index values approaching 1. This highlights the need to explore the underlying factors driving these regional outcomes.

The economic structure of these regions plays a key role. Areas like East Kazakhstan and Akmola, with dominant mining industries, are more vulnerable to corruption due to public contracts and licensing processes. Similarly, Kostanay's agricultural sector, central to its economy, is prone to corruption in land allocation, subsidies, and procurement. The economic importance of these sectors likely amplifies the impact of corruption on development, making the correlation more pronounced.

Governance and anti-corruption measures also influence the observed relationship. Regions like East Kazakhstan and Akmola benefit from stronger institutional frameworks and more effective enforcement of anti-corruption policies, enhancing the reliability of the corruption data and its link to development outcomes. Akmola's proximity to the capital likely supports more rigorous anti-corruption efforts.

In contrast, regions with lower index values (0.4 to 0.54) show a weaker relationship between corruption and development, which may suggest that corruption is less pervasive or concentrated in specific sectors. Economic diversity or less effective governance could dilute the impact of corruption in these regions. In regions with index values below 0.36, the weak correlation does not indicate low corruption levels but may reflect data limitations, such as incomplete or inaccessible records of corruption-related activities, or corruption in sectors not captured by the analysis. It may also suggest that corruption is spilling over from regions with stronger anti-corruption efforts.

In summary, regional variations in the corruption index reflect a complex mix of demographic, economic, governance, and cultural factors. These findings underscore the need for tailored anti-corruption strategies for each region. Future research should explore these factors in more detail, expanding the analysis to include additional sectors and indicators.

Conclusions

The analysis revealed that the relationship between corruption and regional development indicators in Kazakhstan varies significantly across different regions. In some areas, the correlation between corruption and these indicators is more pronounced, while in others, it is either negligible or only evident in specific aspects. The city of Shymkent stands out as an anomaly in this context, indicating a need for further investigation to explain its unique findings.

Several avenues for further development of this study's findings are possible. First, acquir-

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ing data on the number of officials per region and the risks of punishment for corruption could help calculate regional corruption risks, enhancing the integral index to predict hidden or potential corruption. Second, regression analysis could quantify the interaction effects between corruption and regional development indicators. Third, the results could help identify patterns in regions with similar indicators, facilitating a deeper understanding of the underlying causes of these relationships. Cluster analysis could be particularly useful for this purpose.

Additionally, analysis of how corruption impacts various aspects of regional development, such as healthcare, education, and other social sectors, could reveal important trends and inform more targeted anti-corruption strategies. Understanding the influence of cultural, economic, and political contexts on corruption's relationship with development indicators could also clarify regional disparities. Incorporating qualitative data through case studies or interviews with local officials and stakeholders would provide more detailed insights into the mechanisms behind these correlations. Expanding the dataset to include more recent data and additional variables would strengthen the analysis.

These approaches could lead to a more comprehensive understanding of how corruption affects regional development in Kazakhstan. By identifying the unique characteristics and challenges of each region, policymakers can create more effective, targeted anti-corruption strategies, promoting sustainable economic growth across Kazakhstan's diverse regions.

In conclusion, while this study has offered valuable insights into the regional dynamics of corruption and development, ongoing research and data collection are essential for improving and adapting anti-corruption measures. This study provides a foundation for these efforts, emphasizing the importance of a tailored, region-specific approach to combat corruption and foster regional development.

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Key factors in managing creative reindustrialization strategies

ABSTRACT
Relevance The growing importance of creative industries in Russia's economy underscores the need for effective management strategies to support the reindustrialization of second-tier cities, with a focus on socio-economic growth and the preservation of local identity.
Research Objective The article aims to identify key factors that influence the development and implementation of creative reindustrialization strategies in second-tier cities.
Data and Methods Using econometric modeling, the study analyzed data from 50 industrial cities in Sverdlovsk and Chelyabinsk regions (2010–2024), sourced from the Federal State Statistics Service, the Ministry of Construction, Housing and Utilities, and the Presidential Grant Foundation.
Results. The study identified key factors contributing to the growth of creative industries, including the expansion of creative sector companies, proximity to regional centers, increased grant applications, the presence of manufacturing enterprises, growth in local government revenue, and the development of new housing. A comprehensive set of government support measures was proposed, encompassing infrastructure development, financial assistance, educational initiatives, informational resources, and regulatory improvements.
Conclusions Essential government support to creative industries should include infrastructure development, simplified administrative procedures, tax incentives, institutional and legislative backing, and export promotion. Other support measures can be tailored to the chosen management strategy and regional needs, resulting in the creation of a flexible system centered around local identity.

KEYWORDS
creative industry, creative economy, development factors, government support, public policy, management strategy, industrial city, second-tier cities

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Факторы формирования и реализации стратегий управления креативной реиндустриализацией

АННОТАЦИЯ
Актуальность. Повышение значения креативных индустрий в экономике России ставит проблему разработки эффективных стратегий управления, положительно влияющих на процесс реиндустриализации городов второго эшелона. При этом конечной целью является социально-экономический рост городов при сохранении локальной идентичности территорий.
Цель исследования. Выявление факторов, обуславливающих формирование и реализацию стратегий управления креативной реиндустриализацией в городах второго эшелона
Данные и методы. Выявление наиболее значимых факторов было проведено с помощью эконометрического моделирования. Тестирование проводилось на выборке данных по 50 промышленным городам Сверд-

КЛЮЧЕВЫЕ СЛОВА
креативная индустрия, креативная экономика, факторы развития, государственная поддержка, государственная политика, стратегия управления, промышленный город, города второго эшелона

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ловской и Челябинской областей за период с 2010 по 2024 гг. Данные для анализа были собраны из базы данных показателей муниципальных образований Федеральной службы государственной статистики, Министерства строительства и жилищно-коммунального хозяйства Российской Федерации, Фонда президентских грантов.
Результаты. Результаты показали, что положительно влияют на развитие креативных индустрий следующие факторы: рост компаний креативного сектора, расстояние до регионального центра, факт подачи заявок на гранты, количество обрабатывающих и добывающих предприятий, рост доходов местного бюджета, ввод нового жилья. Разработан комплекс мер государственной поддержки, обеспечивающих реализацию стратегий управления креативными индустриями по следующим видам: инфраструктурная, финансовая, образовательная, информационная, регуляторная.
Выводы. Сделан вывод о том, что важными и первоочередными видами государственной поддержки является инфраструктурная поддержка креативных индустрий, упрощение административных процедур, налоговая стимуляция, институциональная и законодательная поддержка, а также помощь в продвижении экспортных товаров и услуг креативного бизнеса. Остальные виды государственной поддержки могут применяться в зависимости от выбранной стратегии управления креативными индустриями и особенностей территории, тем самым формируя модульную систему управления, ядром которой является локальная идентичность.

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ДЛЯ ЦИТИРОВАНИЯ
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创造性再工业化管理战略的形成和实施因素

摘要
现实性：创意产业在俄罗斯经济中的重要性与日俱增，这就产生了一个问题，即如何制定有效的管理战略，对二线城市的再工业化进程产生积极影响。在这种情况下，最终目标是在保持地方特色的同时实现城市的社会经济增长。
研究目标：确定二线城市形成和实施创意再工业化管理战略的决定因素。
数据与方法：文章利用计量经济学模型确定了最重要的因素。对斯维尔德洛夫斯克州和车里雅宾斯克州 50个工业城市2010年至2024年的数据样本进行了测试。分析数据来自联邦国家统计局、俄罗斯联邦建设与住房和社区服务部以及总统补助基金的城市实体指标数据库。
研究结果：结果表明，以下因素对创意产业的发展有积极影响：创意产业公司的增长、与地区中心的距离、申请补助金的事实、制造和采矿企业的数量、地方预算收入的增长以及新住房的投入使用。为确保创意产业管理战略的实施，国家制定了一套支持措施，包括以下几类：基础设施、财政、教育、信息、监管。
结论：国家支持的重要和优先类型是为创意产业提供基础设施支持、简化行政程序、税收优惠、机构和立法支持，以及协助促进创意企业的出口产品和服务。根据所选择的创意产业管理战略和当地的具体情况，还可以采用其他类型的国家支持方式，从而形成一个以当地特色为核心的模块化管理系统。

关键词
创意产业、创意经济、发展要素、国家支持、国家政策、管理战略、工业城市、二线城市

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Introduction

As the process of localization gains momentum worldwide, there is an «increased interest in the local, and consequently, the value of local cultures» (Auzan et al., 2022). This trend makes the strategic management of creative reindustrialization crucial for the development of small and medium-sized cities. The process varies significantly, shaped not only by the initial level of development but also by various factors influencing the

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dynamics of industrial cities (). A key task here is to strengthen local identity, which forms the foundation for designing and implementing a management strategy. This strategy focuses on developing the urban creative economy, leveraging local resources, and supporting projects that attract people and foster prosperity (Kazakova, 2020).

A pivotal aspect of regional policy that can drive sustainable development is the growth of the creative sector and its increasing share in the gross regional product (GRP) (Turgel et al., 2023). Regions and provincial cities hold significant potential, which can be unlocked to transform urban spaces, industrial sites and zones (Turgel & Antonova, 2023). This transformation can create creative clusters, art residencies, and other infrastructure projects (Vlasova et al., 2021; Bugrov, 2022).

Global experience shows that the development of creative clusters helped deindustrialize old industrial regions and attract new investments (Bonello et al., 2020). Russia's former industrial cities are characterized by uneven urban development, resulting in abandoned factories and deteriorating residential areas. In this context, the research by Antonova et al. (2023) is of interest, where the authors propose the concept of «creative reindustrialization» as a new form of economic transformation in industrial cities through the development of creative activities.

To ensure sustainable development, regional policy should focus on increasing the creative economy's share in GRP, which should be supported by clear regulations and targeted mechanisms. However, regional differences in defining creative industries (Abankina et al., 2022) make it challenging to identify sector companies and measure the size of this sector accurately. However, with the introduction of Federal Law No. 330-FZ in August 2024, this issue can be considered resolved, at least at the legislative level[1]. The law mandates the creation of a register of creative industry companies, which will help identify creative sector organizations in different regions and establish a comprehensive accounting system, thereby facilitating further support for the creative economy.

However, global experience in the development of creative industries clearly demonstrates that urban policy cannot be «universal» and must avoid «copying» (Imperiale et al., 2021). To develop individualized management policies for each region, it is important to preserve and emphasize its local identity, which is a critical resource for the development of the creative sector (Turgel et al., 2023). Russian policy in the field of creative industries is still in its early stages, as are academic discussions on the subject, which are currently limited to qualitative assessments and analytical reviews (Boos et al., 2023). As the regulatory framework, grant-based funding systems[2], and regional support programs for creative entrepreneurs evolve, the need arises to analyze the factors influencing the creative industry's growth. This will help identify key growth drivers and inform the development of region-specific funding policies.

This article aims to identify the factors that determine the formation and implementation of creative reindustrialization management strategies in second-tier cities.

The research objectives are as follows:

1. To analyze the factors influencing the management of creative industries in second-tier cities using econometric analysis;

2. To determine the significance of factors for the three strategies of managing creative industries: conservation, transformation, and generation;

3. To develop a comprehensive set of state support measures that ensure the implementation of creative industry management strategies using a modular approach.

The tasks outlined above determined the structure of this paper. The first part presents a quantitative analysis of the factors using econometric modeling. The second part evaluates the significance of the factors for each of the three creative industry management strategies: conservation, transformation, and generation. The final section proposes a set of state support measures designed to create conditions for implementing creative industry management strategies based on a modular approach.

The novelty of the research lies in identifying and assessing factors that shape creative reindustrialization strategies in second-tier cities.

[1] Federal Law No. 330-FZ of 08.08.2024 «On the Development of Creative Industries in the Russian Federation»

[2] The main source of funding for creative industries in Russia at the moment is the Presidential Fund for Cultural Initiatives. Available at: https://xn--80aeeqaabljrdbg6a3ahhcl4ay9hsa.xn--p1ai/public/application/cards

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For management strategies aimed at creative reindustrialization in second-tier cities to succeed, they must be grounded in local identity and consider the factors that shape and support these strategies. This study considers these factors as tools to promote and strengthen locality, ensuring the successful implementation of creative industry management strategies. Additionally, state support measures realized at the municipal level can enhance these factors' impact on the urban creative economy and maximize the effectiveness of the strategy.

The findings may be of interest to regional and municipal authorities, as well as other stakeholders, in developing strategies to transform old industrial cities into talent hubs, driving their successful revitalization.

Theoretical Framework

The analysis of theoretical and empirical studies shows the importance of researching the factors that influence creative economy development, particularly for scholars and experts involved in regional policy-making.

Most articles on policies regulating creative industries and the role of institutional development suggest that the number and diversity of creative industries positively impact urban economies (Yum, 2016). A significant portion of the literature focuses on the development of creative industries in industrial regions. Some authors argue that the strong presence of traditional industries limits the entry of non-extractive sectors in regional markets. Breul & Nguyen (2022) show that effective regional institutions can help reduce the negative impact on regional diversification.

Research on creative industry management policies also highlights the importance of social aspects of economic development, such as creating a favorable business climate, fostering local leadership, promoting tolerance, and building social capital. In this context, local administrations play a key role as organizers of these processes (Fazlagić & Szczepankiewicz, 2020). Government institutions are often the central figures determining financial support for creative industries, as creative businesses are considered high-risk for outside investors (van Blitterswijk, 2019). In Russia, grant support from the government depends both on experts from the Presidential Fund for Cultural Initiatives[3], who help allocate federal funds for cultural and artistic projects, and on regional government institutions responsible for overseeing grant applications and co-financing projects. In global practice, state financial support is not always direct and may also involve indirect support measures. For example, in 2018, the European Council supported a reduction in VAT on digital publications, which contributed to the increased consumption of cultural goods (Borowiecki &Navarrete,2016).

An alternative to government funding for cultural projects in the US and Europe is crowdfunding platforms, which saw significant growth during the COVID-19 pandemic (Handke & Dalla Chiesa, 2022). Crowdfunding platforms enable the execution of creative projects that engage large groups of people (Cicchiello et al., 2023), though they are still underutilized in Russia.

For this study, we used the number of grant applications submitted by municipalities in our sample as an indicator. Given the specific nature of creative industry funding in Russia, this indicator reflects the activity of local authorities in securing federal funding. Since the local budget is the primary source of co-financing for creative projects, we also included indicators of local budget revenues (revbudget) and expenditures (expbudget), as well as investments in fixed capital funded by municipal budgets (invest).

The literature on the development of the creative sector places a special emphasis on the spatial aspect, particularly the impact of the geographical clustering of creative industries as a factor that stimulates the economic growth of a region (Fleischmann et al., 2017). The authors argue that the creation of a creative sector should not be imposed «top-down,» but should instead emerge organically from the development of communication networks and knowledge exchange among entrepreneurs, who are typically concentrated in specific areas. They justify this by emphasizing the need for clustering creative enterprises to maintain their competitiveness. Tomczak & Stachowiak (2015) discuss the selection of optimal criteria for analyzing spatial and locational aspects. Liu et al. (2015) consider the issue of urban planning re-

[3] Official website of the Presidential Fund for Cultural Initiatives. Available at: https://xn--80aeeqaabljrdbg6a3ahhcl4ay9hsa.xn--p1ai/?ysclid=m1en697dyh3753572

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structuring in connection with the development of creative industries, using industrial cities in China as an example. Fazlagić & Szczepankiewicz (2020) argue that the proximity to a metropolitan area is a key factor in the development of creative industries, equating its importance to the level of local government involvement. The clear influence of this factor led to the inclusion of the distance from the regional center (dist) as an indicator in our research model.

The set of socio-economic factors to be considered encompasses aspects such as urban competitiveness and its connection to the creative economy. Urban competitiveness is a multifaceted concept that includes economic indicators, urban development potential, attractiveness, and human capital (Li, X., 2020). These factors influence the development of the creative economy in different ways. Li (2019) highlights human capital as the most critical factor. Consequently, urban management strategies should prioritize support to creative organizations in creative industries first, followed by efforts to attract labor resources. In our model, we selected the Urban Environment Quality Index (urbanind) as an indicator of the competitiveness of Russian cities, along with migration growth rates (migr).

Most articles on socio-economic factors focus on how specific indicators drive the growth of creative industries. We, however, focused on indicators relevant to industrial cities. For example, in former industrial regions, the growth of creative industries depends on the interaction between creative businesses and industrial real estate. Creative industries play a crucial role in transforming post-industrial real estate, such as repurposing inactive industrial zones and abandoned factory buildings into income-generating creative spaces (Kiroff, 2020). This trend is also evident in Russia, particularly in the rapidly developing Ural region (Kurumchina, 2022). Given the selection of industrial cities in our research, one hypothesis suggests that the number of manufacturing (manufactcompany) and mining enterprises (miningcompany) influences the development of the creative sector.

Rollman (2024) highlights the significant influence of developers on the cultural and arts sector, particularly regarding what, where, and how art is positioned, which, in turn, affects government funding for specific creative projects. Additionally, the creation of creative clusters and venues attracts both human labor resources and tourist flows, necessitating the development of a robust accommodation infrastructure (Waitt & Gibson, 2014). These considerations led us to include in our model the indicator of available places in collective accommodation facilities (places hotel) and the number of residential buildings commissioned in a municipal area (house).

In multifactor models of creative industry development, a group of social and cultural variables is identified among the significant factors positively influencing the creative sector. These include private spending on culture, the creativity index, government spending on culture, the number of patents, and the tolerance index (Martinaitytė & Kregždaitė, 2015). Research on factors influencing the development of cultural and creative industries in China revealed several key positive factors, such as advancements in technology, supportive policies, state financial support, human resources, social culture, and the cultural consumption environment (Li & Liao, 2021). In both studies, the dependent variable was the added value of creative industry enterprises, which serves as an indicator of their development. Thus, the proposed models for evaluating the creative industries fail to fully reflect their unique characteristics, treating them like any other economic sector. However, we align with Loots and Witteloostuijn (2018), who consider companies in the creative sector as a special case. For creative professionals, the motivation system differs significantly from that of other entrepreneurs, with the act of creative behavior itself being a key factor in their utility. As a result, creative entrepreneurs often struggle to delegate creative production tasks to employees. This, in turn, limits the growth of personnel in creative firms and imposes conscious constraints on their scale and profitability. Given this peculiarity, we propose to assess the growth of the creative business not in terms of a firm's revenue growth but by the increase in the number of creative industry enterprises. This consideration determined the choice of the dependent variable in our model, favoring the number of organizations in the creative sector. Finally, it should be noted that studies on the development of creative industries in Russia vary in their approaches, methods, and data, with most being theoretical, conceptual, qualitative, or thematic in nature. There is, however, a lack of research using statistical and factor analysis to examine the

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factors shaping and implementing management strategies for creative industries, which is a gap partially addressed by our work.

Methods and Data

Testing was conducted on a dataset from urban districts in Sverdlovsk and Chelyabinsk regions (Appendix 1). The sample consists of panel data for 50 cities in these regions, covering the period from 2010 to 2024. Data for the analysis were collected from official sources, including the database of municipal indicators from the Federal State Statistics Service, as well as websites of relevant agencies such as the Ministry of Construction, Housing, and Utilities of the Russian Federation and the Presidential Grant Foundation.

To test the previously formulated hypotheses, spatial, economic, social, and institutional indicators of the selected cities were gathered (Appendix 2). Some indicators contain missing values due to the specificity and limited availability of the data.

To achieve the first research objective, four hypotheses were tested: (1) Cities located farther from the regional center have fewer incentives to develop creative businesses; (2) The submission of grant applications is a significant factor that stimulates the growth of creative businesses; (3) Manufacturing and mining enterprises have a significant impact on the development of the creative sector: the more such companies a city has, the greater is the number of creative businesses; and (4) The submission of grant applications by municipalities is a significant factor that stimulates the growth of creative businesses. The results of the model served as the foundation for achieving the second and third objectives of this study.

The initial model specification was chosen in a functional form where, for normalization purposes, some factors were taken in logarithmic form (e.g., the number of manufacturing and mining enterprises), while other factors remained unchanged (e.g., the Urban Environment Quality Index).

The selected model specification is as follows (1):

$$y_{it} = \alpha_{it} + \Sigma\beta_{it} \ln x_{it} + \Sigma\gamma_{it} z_{it} + \varepsilon_{it}. \quad (1)$$

In estimating our panel data, we followed the traditional approach, using three main methods: the pooled ordinary least squares (POLS) method, the fixed effects (FE) method, and the random effects (RE) method. An important step in this process is testing the data for heteroskedasticity, endogeneity, multicollinearity, and serial autocorrelation, and then making adjustments to the results based on the characteristics of the data being tested.

Results

The Hausman test shows that the most appropriate method for analyzing the sample is fixed effects estimation. The modified Wald statistic for groupwise heteroskedasticity in the residuals of the fixed-effects regression model revealed the presence of heteroskedasticity, meaning that adjustments for heteroskedasticity are necessary to obtain consistent estimates. The Wooldridge test showed the presence of serial autocorrelation in the model. Testing various model specifications for multicollinearity led to the exclusion of certain factors from the analysis (e.g., population size, number of SMEs). The final estimates of the model using fixed and random effects methods, with corrections for heteroskedasticity and autocorrelation, are presented in Table 2.

Certain factors in the different tested specifications show estimates and significance levels that contradict the overall logic of the analysis. For instance, if we focus on the results obtained from the fixed effects method, we would conclude that the submission of grant applications in the creative industries negatively affects the growth of sector companies, while the industrial base of the city, represented by manufacturing and mining enterprises, is an insignificant factor. It is also important to note that, due to the causal relationships between the dependent and independent variables in the model, there is a potential endogeneity issue that skews the final estimates. In this case, we assumed that the estimates are inconsistent, and they also fail to account for the dynamic nature of the data. It is assumed that the dependent variable may be influenced not only by factors from the current period but also by factors from previous periods. In such a case, the fixed or random effects methods for panel data may yield inconsistent estimates. Therefore, the most effective method in this case is the Generalized Method of Moments (GMM), which allows for the inclusion of lagged values of variables in the model (Wooldridge, 2001). Another key advantage of this method is its ability to account for potential endogeneity and correct the issues mentioned above.

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Table 1

Results of panel data testing with fixed effects, random effects, and the generalized method of moments

Variable	Description of the variable	FE with correction for heteroscedasticity and autocorrelation	RE with correction for autocorrelation	GMM
L1.Lnum_c	Lag value (first level) of creative sector companies	–	–	0.504***
L2.Lnum_c	Lag value (second level) of creative sector companies	–	–	0.107**
dist	Distance from the regional center, km	–	0.001*	–0.0008***
appl_dummy	Dummy variable for grant applications (1 – yes, 0 – no)	–0.101***	–0.1	0.035**
lmanmin	Logarithm of the number of extraction and manufacturing enterprises	0.111	0.767***	0.212***
lrev	Logarithm of the total revenue of companies across all sectors of the economy	0.079**	0.029	-
L1	Lag value (first level)	–	–	0.071***
urbanind	Urban Environment Quality Index	-0.009***	0.003	–
L2	Lag value (second level)	–	–	0.0007
lrevbud	Logarithm of local budget revenues	0.048	0.037	–
L1	Lag value (first level)	–	–	0.111***
lhouse	Logarithm of housing construction	0.102**	0.189***	–
L2	Lag value (second level)	–	–	0.038**

Note: L1 – first-level lag, L2 – second-level lag. * – 10% significance level, ** – 5% significance level, *** – 1% significance level.

Source: compiled by the authors

After testing various specification options, the following results were obtained (Table 1).

The results of the GMM testing consider the specific nature of the analyzed data and provide consistent estimates. As a result, the final conclusions, based on the previously stated hypotheses, are drawn from the estimates obtained using the GMM method.

Discussion

The quantitative analysis revealed several factors that positively influence the growth of creative industries in the selected sample of industrial cities.

1. **The growth of creative sector companies in the previous two years stimulates the creation of creative businesses in the current year,** which can be explained by the factors shown in Figure 1.

Creation of a favourable ecosystem. Successful companies in the creative sector create an environment that attracts new entrepreneurs in several ways. First, they attract and train talented specialists who may later start their own businesses, building a pool of experienced professionals ready for new challenges. Second, the growth of creative businesses fosters the development of infrastructure, as creative clusters (such as hubs and accelerators) form around successful companies, offering new entrepreneurs resources and collaboration opportunities (Evmenov et al., 2023). Third, successful creative industry companies attract investments to the creative sector as a whole, making it easier to secure funding for startups.

The emergence of new niches and opportunities in the creative business sector. The success of major creative companies drives the search for new ideas and approaches, fostering competition and innovation. These innovative technologies and tools, initially funded by large corporations, gradually become accessible to small businesses, encouraging their growth, which opens up new niches and opportunities for new market participants. Furthermore, research shows that the success of creative products shapes new consum-

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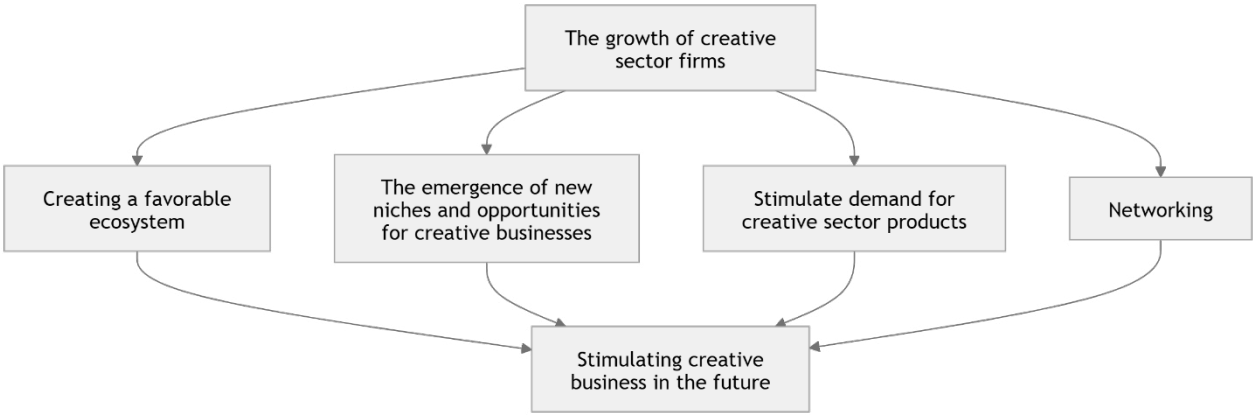

***Figure 1**. Impact of the growth of creative sector firms on the creation of creative businesses.*
Source: compiled by the authors

er habits and preferences, offering opportunities for companies that provide novel solutions in this field. A compelling example is Taiwan, where innovative approaches to cultural and creative product packaging are being developed. These methods are viewed as tools to enhance the country's «soft power,» boost industrial competitiveness, and showcase the unique character of the region (Lin & Lin, 2022).

Stimulation of demand. The development of companies in the creative sector raises public awareness of creative products and services (Yuniarti et al., 2024), thereby stimulating demand and creating favorable conditions for new market entrants. Additionally, large companies gradually build trust in the creative sector, making it more attractive both for investments and for consumers.

Networking. Established companies often interact with other participants in the creative sector, forming a network of connections that can be valuable for newcomers. Wohl (2022) demonstrates that the social networks of entrepreneurs in the creative industries and their interactions within these networks influence both the process of creative collaboration and the resulting innovations. Consequently, various formats of network interactions open up opportunities for collaboration, joint projects, and the exchange of experience.

All these factors contribute to the situation where the growth of companies in the creative sector creates a positive feedback loop, stimulating the emergence of new creative enterprises.

2. The distance to the regional center as a significant factor. Cities located farther from regional centers have fewer incentives to establish creative businesses.

Figure 1 illustrates the concentration of creative industry companies in the cities of Sverdlovsk and Chelyabinsk regions. In Sverdlovsk region, creative sector companies tend to cluster around the administrative center, Yekaterinburg (highlighted in red). In contrast, in Chelyabinsk region, creative industries are less centralized around the city of Chelyabinsk, though a trend toward spatial connectivity is still observed, which suggests the need for further research into creative business networks in neighboring municipalities.

The results align with the evidence from other studies (Fazlagić & Szczepankiewicz, 2020) and can be explained by several factors:

Limited access to resources. Despite the availability of federal grant programs to support creative industries, regional and local funding sources still play a crucial role. Remote areas have fewer available investments and grants and are characterized by a more pronounced lack of basic knowledge and skills, and limited market access (Sugiardi, 2024). However, integrating regional development institutions and accounting for local conditions can help level the playing field for entrepreneurs. For example, the Sverdlovsk Regional Fund for Entrepreneurship Support provides low-interest loans[4] and comprehensive consulting and educational services to small businesses in the region.

[4] Official website of the Sverdlovsk Regional Entrepreneurship Support Fund (SOFPP). Access mode: https://sofp.ru/?ysclid=m3sb2sn6qr234476414

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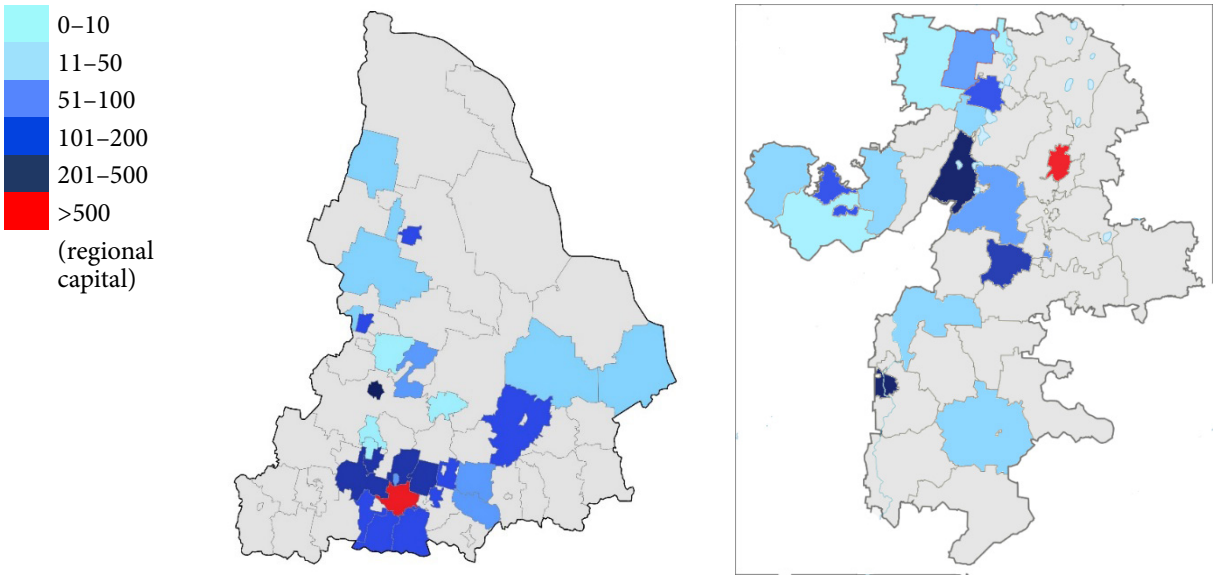

Figure 1. *Concentration of registered creative industry companies in Sverdlovsk region (left) and Chelyabinsk region (right)*

Source: compiled by the authors

Quality of human capital. A shortage of skilled professionals in fields vital for creative businesses—such as design, programming, and marketing—due to talent migration to regional centers is a key challenge for developing creative industries in small cities (Gulyaeva, 2019). Additionally, fewer residents in small cities are willing or able to take the risk of starting their own businesses. Additionally, the problem could be addressed by developing reliable transportation infrastructure and modern creative spaces (such as coworking spaces and creative hubs), as well as by ensuring access to cutting-edge technologies and equipment, which are now mostly available in central areas.

Network support. The farther a settlement is from the administrative center, the fewer business incubators and accelerators are available to foster creative businesses. Consequently, there are fewer opportunities for in-person support and mentorship from experienced entrepreneurs and investors, as well as for collaboration and networking with peers and experts. Despite these challenges, online learning can effectively mitigate some of these issues. Moreover, creative industries tend to thrive in clusters, where companies can easily collaborate. In cities far from administrative centers, creative clusters develop more slowly, are smaller in scale, and have less developed infrastructure (Turgel et al., 2023).

Overall, cities located far from regional centers face a set of interconnected challenges that make establishing creative businesses more difficult and risky. These problems could be addressed through a comprehensive approach that includes investments in infrastructure, support for education and entrepreneurship, and the development of attractive living and working environments.

3. **Grant application submission is a significant factor, which stimulates the growth of creative businesses** for the following reasons**:**

Encouraging the development of creative economy strategies. To apply for a grant, entrepreneurs need to clearly articulate their business idea, conduct a market analysis, identify their target audience, and create a financial model. This process makes a valuable experience in itself, even if the application is rejected. Since creative industry projects funded by the Presidential Fund are co-financed by local and regional authorities, these authorities actively participate in preparing applications, giving them the opportunity to influence the development of specific creative industry sectors in their regions.

Receiving feedback and expertise. Even if an application is declined, applicants often receive valuable feedback from experts. This helps improve the business plan, identify weaknesses in the creative project, and make the necessary adjustments to enhance the planned business's com-

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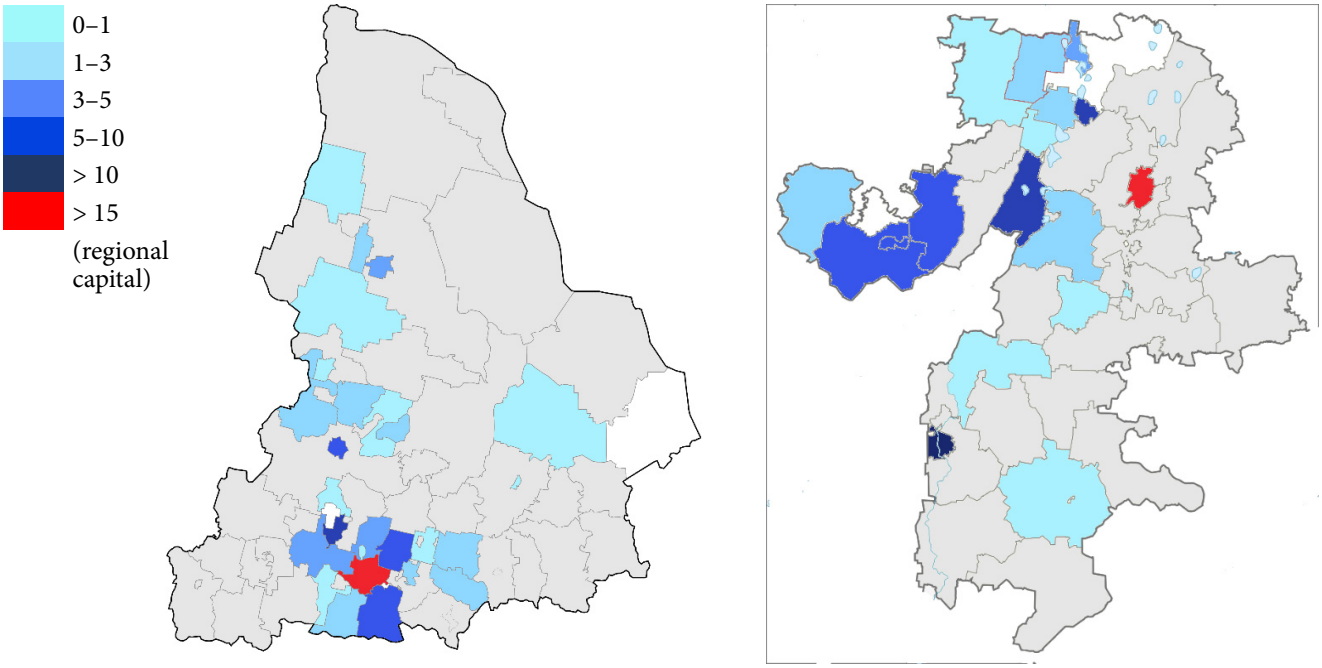

Figure 2. *Average number of grant applications submitted in Sverdlovsk region (left) and Chelyabinsk region (right) for 2021–2024 .*

Source: compiled by the authors

petitiveness. Thus, increasing the number of applications helps refine the skills needed to develop successful projects.

Building entrepreneurial confidence. Submitting an application and receiving positive feedback (even without funding) can significantly boost entrepreneurs' motivation and confidence in their future success. Preparing an application mobilizes entrepreneurs, prompting them to study their business and market more deeply, contributing to their professional growth. Successful grant applications often require innovative solutions and approaches, which stimulates the development of creative potential. New methods of promoting creative startups via digital platforms also seem promising. For example, Shaimiev et al. (2023) propose creating a «scientific and technical creative show» on digital platforms, involving viewers in the development process of startups.

The spatial distribution of grant applications shown in Figure 2 closely mirrors the intensity patterns in Figure 1, which reflect the concentration of creative industry companies in Sverdlovsk and Chelyabinsk regions. This suggests a potential correlation: municipalities with more grant applications tend to have a higher concentration of creative industries.

4. **Positive correlation between the number of manufacturing and extractive enterprises and the development of the creative sector.** At first glance, this correlation may seem unexpected, but several factors can explain this phenomenon:

Growing demand for innovation and technological solutions. Manufacturing and extractive enterprises constantly require innovative technological solutions to improve production efficiency, reduce costs, and enhance product quality (Kurlikova et al., 2024). Cross-innovation cooperation between creative and «non-creative» industries is viewed as a key driver of socio-economic development in the near future (Babina et al., 2024). This creates demand for the services of creative companies specializing in software development, process automation, industrial design, and related fields.

Attracting investments. Large manufacturing and extractive enterprises draw significant investments into the region, fostering a favorable environment for the growth of other industries, including the creative sector. These investments may be directed toward building infrastructure needed by creative companies. Additionally, industrial enterprises create numerous jobs, leading

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to population growth and increased purchasing power, which in turn stimulates demand for creative products and services.

Emergence of new markets and opportunities. Manufacturing and extractive enterprises require effective branding and marketing strategies to promote their products in the market, which creates opportunities for collaboration with creative agencies and specialists in design, advertising, and PR. Furthermore, manufacturing and extractive enterprises often become attractions for industrial tourism, opening new possibilities for creative companies involved in developing tourist routes, producing souvenirs, and organizing events (Konstantinova & Panchenko, 2022).

5. **Increase in local budget revenues is a significant factor that positively influences the emergence of creative businesses in a city,** which can be explained by several reasons:

Funding support programs, including for businesses. The growth in budget revenues allows the city administration to increase funding for grant programs and subsidies for emerging creative enterprises. Additional funds can be directed toward the development of educational programs in the creative industries to enhance the skills of local entrepreneurs and specialists. Moreover, city authorities can invest in promoting the city's creative industries at regional and international levels.

Creating a favorable regulatory environment. Additional resources enable the city administration to optimize bureaucratic processes, making business registration and management easier. Increased budget revenues also allow the city administration to create more favorable tax conditions for creative enterprises, fostering their growth.

Enhancing investment appeal. An increase in budget revenues indicates economic growth in the city, making it more attractive to private investors who may invest in creative projects.

Improving quality of life. Additional funds enable the city administration to enhance social infrastructure—such as education, healthcare, and culture—thereby attracting qualified specialists, improving the overall quality of life, and benefiting the creative class.

6. **The introduction of new housing stimulates the development of creative businesses for several reasons:**

Influx of population and increased demand. Access to new housing stimulates population growth, expanding the potential market for creative products and services. New residents create demand for interior design, landscaping services, entertainment, cafes, restaurants, and other services often provided by creative enterprises. Additionally, new residential complexes enlarge the pool of potential employees for creative businesses. Many creative enterprises require talented individuals, and the availability of housing can facilitate the search for qualified personnel.

Formation of new creative projects. New residential areas often become hubs for emerging communities, where people interact and socialize. This environment fosters the creation and development of collaborative creative projects and exchange of ideas. Developers frequently invest in the infrastructure of new neighborhoods, including roads, parking spaces, and public areas, which creates a more attractive environment for living and working and, in turn, draws creative professionals and entrepreneurs.

In general, the development of new housing catalyzes creative business growth but is most effective when paired with infrastructure improvements and a supportive business environment.

Assessment of the key factors in the implementation of creative industry management strategies

Table 2 identifies the importance of previously determined factors (and their underlying causes) for three creative industry management strategies: conservation, transformation, and generation. A scoring system from 0 to 2 was used to evaluate the significance of each underlying cause, ranging from «low» (0) to «high» (2). The underlying causes are also categorized by types of state support (Table 3), which will subsequently be incorporated into creative industry management strategies.

Our analysis identifies the dominant factors that scored highest across all creative industry strategies (Table 2), with state support for these factors benefiting all three strategy types. The second group of factors, which strengthens the impact of the first group, includes the remaining factors, and their support measures depend on the chosen strategy.

Table 3 shows that the generation strategy for creative industries, aimed at creating new symbolic meanings and material foundations to establish local identity or a territorial brand, requires the

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Table 2

Factors driving creative industry growth for three management strategies

Factors driving the growth of creative industry companies	Types of state support	Creative industry management strategies		
		Dynamic conservation	Transformation	Generation
1. *The growth of creative sector companies in the previous two years stimulates the creation of creative businesses in the current year*				
Creation of a favourable ecosystem.	I	2	2	2
Emergence of new niches and opportunities in the creative business sector	EI	1	2	2
Stimulation of demand	EI	0	1	2
Networking	EI	2	2	2
2. The distance to the regional center is a significant factor. Cities farther from the regional center have fewer incentives to create creative businesses.				
Limited access to resources	F	1	1	2
Quality of human capital	I	2	2	2
Network support	EI	1	2	2
3. *The submission of grant applications is a significant factor and stimulates the growth of creative businesses, encouraging the development of a creative economy strategy.*				
	R	2	2	2
Receiving feedback and expertise	EI	1	2	2
Building entrepreneurial confidence	EI	1	2	2
4. *Positive correlation between the number of manufacturing and extractive enterprises and the development of the creative sector.*				
Growing demand for innovation and technological solutions	EI	2	2	2
Attracting investments	F	2	2	2
Emergence of new markets and opportunities	EI	0	1	2
5. *The growth of local budget revenues is a significant factor that positively influences the emergence of creative businesses in the city.*				
Financing of business support programs	F	2	2	2
Creating a favorable regulatory environment	R	2	2	2
Increase in investment attractiveness	F	2	2	2
6. The introduction of new housing stimulates the development of creative businesses				
Influx of population and increased demand	I	2	2	2
Formation of new communities	EI	1	2	2

Notes: 0 – low factor significance (minimal impact on the formation and implementation of the strategy);1 – moderate factor significance (a supporting factor that amplifies the effect of the dominant factor);2 – high factor significance (a dominant factor critically important for implementing the management strategy).

Source: compiled by the authors

Table 3

Table of distribution of final scores for the significance of factors

Creative industries management strategy	Infrastructure (max=6)	Financial support (max=8)	Education and information support (max=18)	Regulatory support (max=4)	Total (max=36)
Dynamic conservation	6	7	9	4	26
Transformation	6	7	16	4	33
Generation	6	8	18	4	36

Source: compiled by the authors

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highest level of state support for all factors. In contrast, the dynamic conservation strategy is the least dependent on state involvement, as creative industries in this case already have a solid material foundation and a relevant symbolic component of local identity. This conclusion is vital for managing creative industries, enabling strategic sector development while accounting for project costs.

It should be noted that the success of creative industry strategies in second-tier industrial cities depends heavily on state regulatory and infrastructure support, which means that priority measures should include the establishment of creative clusters, simplification of administrative processes, introduction of tax incentives, legislative support, and promotion of creative exports (Table 4). The choice of other state support measures is determined, first, by the type of creative industry management strategy, and second, by the factors that enhance the local identity of the city or region, which reflects the modular approach to management.

To develop an effective creative industry policy for second-tier cities, it is necessary, first, to

Table 4

Measures of state support for the implementation of creative industry strategies

Types of state support	Measures of state support
Infrastructure (**I**)	• *Creation of creative clusters and incubators*: State funding for the development of specialized spaces for creative entrepreneurs, providing access to equipment, offices, and shared collaboration areas. • *Development of technological infrastructure*: Support for modern communication technologies and crowdfunding platforms to facilitate creative startups. • *Support for cultural events*: Organization of exhibitions, festivals, forums, and conferences that promote creative industries and showcase local talent. • *Development of tourism infrastructure*: Development of cultural and historical sites to attract tourists and boost demand for creative businesses.
Financial support (**F**)	• *Grants and subsidies*: Offering grants for startups and projects in the creative sector for small and medium-sized businesses to reduce financial risks. • *Tax incentives*: Providing tax holidays or reduced tax rates for creative companies to ease financial burdens. • *State funding*: Establishing specialized municipal and regional funds to invest in creative projects on preferential terms. • *Loans*: Offering loans to aspiring creative entrepreneurs at reduced interest rates.
Education and information support (**EI**)	• *Training programs and courses*: Developing joint programs with universities and educational institutions to train specialists in creative fields. • *Internships and placements*: Creating internship and placement programs in creative companies for students. • *Workshops and seminars*: Organizing events with experts from various creative industries to promote knowledge sharing and skill development. • *Support for professional associations*: Encouraging the activities of professional organizations in the creative industries. • *Networking platforms*: Developing online platforms and events to connect creative entrepreneurs with businesses, investors, and government bodies. • *Publication of research and reports*: Providing access to up-to-date information on the state of creative industries through studies and analytical reports. • *Marketing support*: Offering information on opportunities for business promotion, market trends, and current developments to help entrepreneurs navigate the economic landscape.
Regulatory support (**R**)	• *Institutional support*: Establishing regional development institutes and industry organizations. • *Simplification of administrative procedures*: Reducing bureaucratic barriers for business registration and operations. • *Intellectual property protection*: Developing and implementing legislative initiatives to safeguard copyrights and patents. • *Municipal legislative initiatives*: Supporting creative industries through locally tailored laws that reflect regional identity. • *Promotion of international cooperation*: Facilitating the export of creative products and services

Source: compiled by the authors

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have a clear understanding of their role in the regional socio-economic system, primarily shaped by local identity; second, to consider the factors that support the formation and implementation of management policies; and third, to create conditions through state support measures that attract new resources and «trigger causal cycles that drive development» (Kazakova, 2020).

Conclusion

This study explores the factors influencing the development strategies of industrial cities in the creative economy to guide effective management decisions (Manaeva, 2023). From the theoretical standpoint, the proposed modular approach can offer a framework for devising and implementing various management strategies for creative revitalization of cities, based on local identity and enhanced by favorable factors through state support. It can also provide regional and local authorities with a more targeted and effective way to implement creative industry development strategies, considering both local conditions and the city's position in the broader regional system (Rastvortseva, &Manaeva, 2022). Importantly, an effective policy for the creative urban economy requires an analysis of key factors and, when necessary, reinforcing them with appropriate support measures.

The econometric analysis shows that the following factors are conducive to the transformation of post-industrial cities into centers of innovative development, competing for human capital: growth in creative sector companies (leading to the emergence of new businesses), distance from the regional center (more remote cities have fewer incentives), grant applications, the number of manufacturing and extractive enterprises, increased local budget revenues, and construction of new housing. If we take these factors into account, we can form and successfully implement creative industry development strategies based on local identity. It should be noted that the limitations of the study, caused by imperfect statistical data (especially municipal statistics) and the incomplete coverage of factors, result in incomplete findings and require the inclusion of additional data in the analysis.

The assessment of factors using a scoring system, reflecting their significance from «weak» (0) to «strong» (2), revealed two groups of factors (dominant and supplementary, which enhance the effect of dominant factors) and clarified their importance for each of the three types of management strategies: dynamic conservation, transformation, and generation. We also found a critical dependence of all types of creative industry management strategies in second-tier industrial cities on state regulatory and infrastructure support.

The next iteration developed support measures for each strategy type, focusing on strengthening the factors that drive successful implementation. The choice of state support measures depends first on the creative industry management strategy and second on factors that enhance local identity, reflecting the modular management approach. The generation strategy, aimed at creating new symbolic meanings and reshaping local identity or regional branding, requires maximum government support. In contrast, the dynamic conservation strategy, based on an established creative cluster with a solid foundation and current symbolic identity, is least dependent on government involvement. The support measures are divided into four areas: infrastructure, financial, educational, informational, and regulatory.

Given that the factors influencing the formation and functioning of cities are dynamic (Sekushina, 2021), there is an objective need to continue their study and analysis, including econometric-based research.

Appendix 1

City districts: Sverdlovsk Region, Chelyabinsk Region

Urban district	Region
Urban District Bogdanovich	Sverdlovsk Region
Verkhnyaya Salda Urban District	Sverdlovsk Region
Novaya Lyalya Urban District	Sverdlovsk Region
Urban District Revda	Sverdlovsk Region
Sysert Urban District	Sverdlovsk Region
Tavda Urban District	Sverdlovsk Region

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Urban district	Region
Tura Urban District	Sverdlovsk Region
Aramil Urban District	Sverdlovsk Region
Asbest Urban District	Sverdlovsk Region
Berezovsky Urban District	Sverdlovsk Region
Urban District Verkhnyaya Pyshma	Sverdlovsk Region
Urban District Verkhny Tagil	Sverdlovsk Region
Urban District Zarechny	Sverdlovsk Region
City of Irbit	Sverdlovsk Region
Kachkanar Urban District	Sverdlovsk Region
Kirovgrad Urban District	Sverdlovsk Region
Urban District Krasnoturyinsk	Sverdlovsk Region
Urban District Krasnouralsk	Sverdlovsk Region
Kushva Urban District	Sverdlovsk Region
Urban District Nizhnyaya Salda	Sverdlovsk Region
City of Nizhny Tagil	Sverdlovsk Region
Urban District Pervouralsk	Sverdlovsk Region
Polevskoy Urban District	Sverdlovsk Region
Severouralsk Urban District	Sverdlovsk Region
Serov Urban District	Sverdlovsk Region
Urban District Sredneuralsk	Sverdlovsk Region
Urban District Sukhoi Log	Sverdlovsk Region
Urban District «City of Lesnoy»	Sverdlovsk Region
Novouralsk Urban District	Sverdlovsk Region
Asha	Chelyabinsk Region
Verkhneuralsk	Chelyabinsk Region
Verkhny Ufaley	Chelyabinsk Region
Karabash	Chelyabinsk Region
Kartaly	Chelyabinsk Region
Katav-Ivanovsk	Chelyabinsk Region
Kyshtym	Chelyabinsk Region
Magnitogorsk	Chelyabinsk Region
Miass	Chelyabinsk Region
Nyazepetrovsk	Chelyabinsk Region
Ozersk	Chelyabinsk Region
Plast	Chelyabinsk Region
Satka	Chelyabinsk Region
Sim	Chelyabinsk Region
Snezhinsk	Chelyabinsk Region
Trekhgorny	Chelyabinsk Region
Ust-Katav	Chelyabinsk Region
Chebarkul	Chelyabinsk Region
Chelyabinsk	Chelyabinsk Region
Yuzhnouralsk	Chelyabinsk Region
Yuryuzan	Chelyabinsk Region

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Appendix 2

Descriptive statistics of variables

Variable	Description of the variable, unit of measurement	Number of observations	Mean	Standard deviation	Min	Max
dist	Distance from the regional center, km.	721	168.2	108.9	0.0	441.0
migr	Migration growth	617	44.1	1154.2	3979.0	12169.0
road	Length of local public roads, km.	618	239.2	219.7	0.0	1200.0
revbudget	Actual local budget revenues, million rubles.	517	2143.4	5189.3	0.0	52210.7
expbudget	Actual local budget expenditures, million rubles.	488	2450.7	5429.8	0.0	52468.2
invest	Investments in fixed capital from municipal budget funds, thousand rubles	608	139351.6	410895.7	0.0	5998091.4
hotels	Number of collective accommodation facilities, units.	478	11.4	16.1	0.0	124.0
placeshotel	Number of beds in collective accommodation facilities, units.	425	899.4	1466.1	0.0	10299.0
house	Residential housing put into operation in the municipal area, sq. m.	621	36292.5	102674.6	0.0	1003602.0
urbanind	Ministry of Construction Ranking / Urban Environment Quality Index	300	184.1	21.4	117.0	243.0
salary	Average monthly salary of employees in organizations, rubles.	554	28381.6	7841.5	11820.7	54542.6
salaryculture	Average monthly salary of employees in organizations (Activities in the field of culture, sports, leisure, and entertainment), rubles.	365	31786.4	9082.8	13433.9	55610.8
population	Average annual population, thousand people.	630	81.5	170.2	6.8	1201.5
sms	Number of small and medium-sized enterprises, units.	231	4561.4	12245.5	237.0	76777.0
revenuetotal	Total revenue, million roubles	301	83201.1	320091.9	0.1	2697339.8
revenuecreative	Revenue of creative industries, million rubles	290	2468.5	11665.9	0.3	108320.9
creativecompany	Number of enterprises in creative industries, units	308	242.1	813.7	0.0	6838.0
manufactcompany	Number of manufacturing enterprises, units	308	162.0	575.6	0.0	4676.0
miningcompany	Number of extractive enterprises, units	308	6.6	20.5	0.0	170.0
grantamount	Presidential Grant Foundation (PGF), grant amount, thous. rubles	199	360.9	1421.8	0.0	16217.3
applications	Number of grant applications submitted	199	4.4	12.7	0.0	103.0
winapplications	Number of grant applications won	199	0.3	0.8	0.0	6.0

Source: authors' calculations

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