Submission date: 21 of December 2025
Acceptance date: 2 of April 2026
Publication date: 8 of April 2026

ECONOMIC COMPLEXITY AND INDUSTRIAL SOVEREIGNTY: TRANSFORMING REGIONAL EXPORTS UNDER GEOPOLITICAL CONSTRAINTS

COMPLEJIDAD ECONÓMICA Y SOBERANÍA INDUSTRIAL: TRANSFORMACIÓN DE LAS EXPORTACIONES REGIONALES BAJO RES-

Irina Danilova[1*]
E-mail: danilovaiv@susu.ru
ORCID: https://orcid.org/0009-0003-9845-0463
Irina Mikhailova[1,2]
E-mail: kilinka@mail.ru
ORCID: https://orcid.org/0009-0000-3916-7279
Evgeny Stepanov[1]
E-mail: stepanovea@susu.ru
ORCID: https://orcid.org/0009-0006-3426-9974
Ksenia Nesytyh[1]
E-mail: postaushkinaki@susu.ru
ORCID: https://orcid.org/0009-0007-3065-6122
[1] South Ural State University, Chelyabinsk, Russia.
[2] Moscow Institute of Physics and Technology (National Research University), Dolgoprudny, Russia.
*Corresponding author

Suggested citation (APA 7th edition)

Danilova, I., Mikhailova, I., Stepanov, E., & Nesytyh, K. (2026). Economic Complexity and Industrial Sovereignty: Transforming Regional Exports under Geopolitical Constraints. ***Universidad y Sociedad, 18***(2). e5925.

ABSTRACT:

The purpose of this study is to develop a strategic tool for identifying directions in the transformation of export activities of Russia's industrial regions, with a focus on the production and supply of goods with high economic complexity in order to strengthen the country's industrial sovereignty. The research employs methods of comparative analysis, index-based approaches, and typologization. The assessment is based on statistics from the Federal State Statistics Service, the Federal Customs Service, the Atlas of Economic Complexity (Harvard CID), and data from the International Trade Centre (ITC). The indices applied include revealed comparative advantage (RCA), product complexity index (PCI), and export concentration index (HHI). The year 2019 was chosen as the base period, as it reflects the stable state of foreign economic activity in the regions prior to the pandemic and sanction pressures. A total of 32 industrial regions of Russia were identified with a high localization of high-tech and medium-high-tech industries. Based on the export structure analysis, leading and base regions were highlighted that possess comparative advantages in the supply of complex products. The results confirm the significance of relying on industrial regions with high export potential of complex products as key drivers of industrial sovereignty. The developed approach expands analytical tools for selecting priority directions of regional policy, providing justification for measures to support complex exports and to form sustainable niches in the global market.

Keywords: Industrial regions, High-tech export, Economic complexity of exports, Comparative economic advantages.

RESUMEN:

El propósito de este estudio es desarrollar una herramienta estratégica para identificar las líneas de acción en la transformación de las actividades exportadoras de las regiones industriales de Rusia, con especial atención a la producción y el suministro de bienes de alta complejidad económica, con el fin de fortalecer la soberanía industrial del país. La investigación emplea métodos de análisis comparativo, enfoques basados en índices y tipología. La evaluación se basa en estadísticas del Servicio Federal de Estadística del Estado, el Servicio Federal de Aduanas, el Atlas de Complejidad Económica (Harvard CID) y datos del Centro de Comercio Internacional (ITC). Los índices aplicados incluyen la ventaja comparativa revelada (VCR), el índice de complejidad del producto (ICP) y el índice de concentración de las exportaciones (ICE).

Se eligió el año 2019 como período base, ya que refleja la estabilidad de la actividad económica exterior en las regiones antes de la pandemia y las sanciones. Se identificaron un total de 32 regiones industriales de Rusia con una alta concentración de industrias de alta y media-alta tecnología. A partir del análisis de la estructura exportadora, se destacaron las regiones líderes y las regiones base que poseen ventajas comparativas en el suministro de productos complejos. Los resultados confirman la importancia de considerar a las regiones industriales con alto potencial exportador de productos complejos como motores clave de la soberanía industrial. El enfoque desarrollado amplía las herramientas analíticas para seleccionar las prioridades de la política regional, justificando así las medidas de apoyo a las exportaciones de productos complejos y la creación de nichos sostenibles en el mercado global.

Palabras clave: Regiones industriales, Exportaciones de alta tecnología, Complejidad económica de las exportaciones, Ventajas económicas comparativas.

INTRODUCTION:

The growth of geopolitical tensions and external sanctions has accelerated the implementation of Russia's spatial policy aimed at strengthening economic sovereignty, intensifying the scientific and technological development of regions, shifting priorities and formats of foreign economic relations, and stimulating the search for new export markets. The aggravation of contradictions in the sphere of international technological specialization, industrial cooperation, and issues of interdependence in the trade of industrial goods has posed challenges for the entire global economy. The new reality of monopolization of strategic and critical technologies, localization of high-tech production, and supply chain disruptions has led to industrial instability and slowed economic growth (Ushkalova, 2022).

Global challenges for Russia, with its high spatial differentiation, have made it urgent to adopt a preventive policy of transitioning toward economic self-sufficiency and multidirectional changes: restructuring the export, industrial, and scientific-technological potential of regions, and adapting to restrictions on openness. Economic sovereignty does not imply complete autonomy or the independent production of all goods, but raises the issue of developing domestic production of technologically complex products, enhancing industrial competencies, updating approaches to participation in the international division of labor, reshaping export structures in line with global market demands, and reducing dependence on foreign trade (Dementiev, 2023). Achieving this goal under conditions of spatial heterogeneity requires identifying the territorial localization of industrial competencies and recognizing regions with potential and comparative advantages in the production of competitive goods. This, in turn, would help to activate internal and external drivers of industrial growth.

The scientific problem requiring resolution is the justification of criteria for selecting directions of foreign economic restructuring in regions, as well as objective parameters that determine different formats of transformation: maintaining openness with new priorities (supply of high-tech and economically complex products), fragmented openness with emphasis on selective product flows without radical restructuring, or a localized regime of maintaining the existing situation with concentration on the domestic market.

The aim of this study is to develop a strategic tool for identifying directions of transformation in the export activities of industrial regions, oriented toward the development of economically complex products in order to strengthen the industrial sovereignty of the Russian Federation.

Under external constraints, the adaptation of Russia's and its regions' foreign trade structures requires solving tasks related to meeting the needs of national industry for expanding production capacities while simultaneously undergoing structural changes that reflect post-industrial trends (Letta, 2024) and prioritize complex products (Minakir, 2023). Together, these factors create conditions for transitioning to a new model of "technological openness", implemented both in developed countries and within the Russian economy.

The theoretical foundation for the practical implementation of these tasks, as reflected in domestic and international sources (Mariotti, 2025; Medvedkov et al., 2024), highlights key trends in the influence of scientific and technological change on international trade: a) the deepening of "technological gaps" (Tagliapietra & Veugelers, 2023) in industrial competencies between countries and regions, resulting in divergent economic growth and negative consequences for "outsider" countries in trade. The larger the gap, the greater the volume of knowledge that must be accumulated, but the weaker the outsider's ability to absorb it (March & Schieferdecker, 2023). Catch-up economies fall into zones of strict regulation of strategic technologies (Luo, 2022) and industrial goods, which sharpens the pursuit of industrial and trade self-sufficiency (the concept of "techno-nationalism" in foreign trade); b) a shift in the priorities of production and exports, emphasizing technology, complexity, innovation, and diversity of traded goods; demand for the development of industries that ensure the technological sovereignty of the economy and the stability of foreign trade (March & Schieferdecker, 2023); c) foreign trade strategies are oriented toward the quality of economic growth but simultaneously take into account potential negative effects (Janger, 2024), especially technological interdependence (the "win–lose" theory (Mariotti, 2024) of trade). For this reason, measures are introduced to align changes in export and industrial policy.

These directions are equally relevant to Russia's economy, where regions are restructuring their export strategies in line with global trends in order to achieve a "delicate compromise" (Mariotti, 2024) between "openness" (maximizing gains) and "strategic autonomy" (Van den Abeele, 2021) (minimizing losses) under sanction-driven constraints on national industry. The course toward transformation and structural shifts in the economy, increasing technological specialization of regions, and expanding trade in industrial goods requires systemic information about sectoral competencies in the production of high-tech goods that meet global competitiveness standards, as well as their localization in specific territorial areas. A key element in transforming regional foreign trade is the interconnectedness of policy decisions, a need highlighted both in international and Russian studies on expanding the high-tech industrial sector and on selecting target priorities for the production and export of goods aligned with the economic complexity standards of the global market.

It is well known that the parameters of economic complexity of non-resource goods are determined by the characteristics of an industry and the exporting economy as a whole. These include: the diversity of the export basket; the presence of goods for which the country has comparative economic advantages; and the uniqueness of supplies compared to the potential of competing countries. The production of complex exports requires that a country/region possess the industrial base and competencies necessary and sufficient for creating and reproducing technologies and innovations. Knowledge of the pool of complex products makes it possible to identify and stimulate promising sectors, specific industries, and launch processes of selective support for regions (Afanasyev & Gusev, 2024).

In Russian scholarship, assessments of economic complexity are more often applied at the country level, while in reality regions are the main actors in foreign economic relations. In this regard, several studies stand out for their systemic approach: the development of the Atlas of Economic Complexity of Russian Regions as a comprehensive assessment of the product space; research into productive national directions for export strategies; and the fundamental study ranking exports of 82 regions according to the criteria of "existing capabilities" (economic complexity) and "capabilities in use" (based on "proximity" and the presence of global comparative advantages). A particularly interesting study examined a unique region—Kaliningrad Oblast—taking into account both international and interregional trade flows when assessing economic complexity. However, there remains a shortage of studies assessing both economic complexity and economic development levels. Only isolated works (Shubin, 2021) have attempted typologies and determination of strategic positions of regions. Thus, there is a clear need for research on Russian regions with sizable high-tech sectors, diverse scales of industry and exports, and the potential for producing goods that meet the complexity criteria of the global product space.

The preceding review of theories and analysis of publications on the economic complexity of exports in Russian regions allows us to conclude that the development and implementation of a strategy for "transforming openness" of the economy under strict sanctions requires knowledge of: the structure of exports and industrial specializations of regions; the presence/absence of comparative economic advantages; the pool of exported high-tech industrial products (industrial competence potential); the degree to which regional trade flows meet the complexity criteria of the global product space; and the level of concentration of these flows within the foreign trade structure. These directions provide an information-analytical basis, serving as a strategic tool for regional policy: simultaneously addressing the demands of industry, the transformation of industrial exports, and the support of target niches within regions. The logic of selecting a region's strategic target segment is shown in Figure 1.

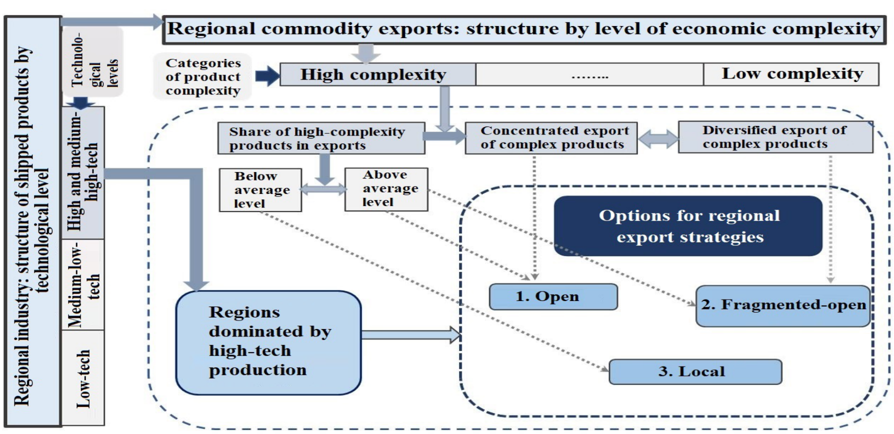

Fig 1. Logical scheme of directions for transforming the export activities of regions.

In the authors' view, the selection of a region's target segment should meet two requirements: first, the export product positions must correspond to a high level of economic complexity (the top quartile of the Product Complexity Index (PCI), which reflects the diversity and sophistication of technologies and production structures required to produce goods accessible to only a limited number of countries). This criterion was used by the authors to position Russian regional exports against global benchmark values. Second, the flows of specialized export goods must demonstrate high concentration, ensuring the formation of a stable niche in international trade in complex products. Differentiation of the economic space of industrial regions, based on the proposed criteria and taking into account accumulated production competencies (high-tech industrial sectors with the potential for large-scale production) and export competencies (comparative advantages at both the Russian and global levels), makes it possible to identify territorial zones with high potential for restructuring product nomenclature and sectoral specialization in the production and export of complex goods. This requires expanding approaches to the transformation of foreign trade.

The authors emphasize that under prolonged sanctions and uneven industrial development, the key role in transforming Russia's economy belongs to regions with concentrated high-tech sectors. At the same time, alternative development scenarios remain possible: a) a course toward new "openness," trading high-tech goods of global complexity levels, creating and consolidating export niches; b) maintaining diversified exports without "ambitions" for leadership in Russia's high-tech industrial segments, while gradually expanding complex product production—"fragmented openness" of the economy; c) conservation of the existing export structure without radical changes—a "localized" development option.

Quantitative analysis of similar export variants in EU countries (facing comparable problems of heterogeneous economic space, industrial technology levels, and the need for structural transformation) confirmed the advantages of economic openness, even under shocks and restrictions. Accordingly, such a course for Russia is deemed reasonable under current circumstances.

It should be noted that the focus on analyzing regional exports from the perspective of technological structure is explained by the fact that such regions serve as hubs for localizing competencies in the production of complex goods. This can be confirmed by parameters used in their classification:

1. the use of a broad set of indicators of scientific, technological, and socio-economic development as jointly determining the status of a region (Byvshev et al., 2024); the application of a system of scientific and technological indicators characterizing potential, infrastructure, performance, and digitalization (Volkova & Romanyuk, 2024); limitation to key metrics, in the authors' view (expenditure on technological innovations, growth rate of current R&D expenditures, inventive activity coefficient, use of a single criterion such as import dependence (Akberdina & Potaptseva, 2023);

2. classification of regions based on ranking types of regional activities by technological level using official statistical classifiers, for example Eurostat, which was applied by the authors.

MATERIALS AND METHODS

The research hypothesis assumes that regional strategies for contributing to the formation of the country's industrial sovereignty depend on the scale of the high-tech sector, the level of economic complexity of export products, and the presence of trade flows with relative advantages at both the global and national levels.

The object of the study is the economy of industrial regions specializing in the production and export of high-tech products. The information base for the analysis includes statistical data from the Federal Customs Service of the Russian Federation, the Federal State Statistics Service, the Unified Interdepartmental Information and Statistical System, the Atlas of Economic Complexity (Harvard CID), the International Trade Centre (ITC), and specialized software products. Official data for 2019 were used, as they allow for analysis outside of a shock environment (before the COVID-19 pandemic and subsequent sanctions/antisanctions) and reflect a period prior to restricted access to customs statistics since 2022. Testing the proposed approach on 2019 data makes it possible to clearly identify accumulated competencies and established export flows of regions with an industrial base for high-tech production. Analysis under stable conditions without shocks or external restrictions helps to reveal persistent internal linkages between economic processes. The diagnostics show the advantages of competitive, high-complexity products, the existence of market positions recognized by global trade, and experience in industrial foreign trade under nonshock conditions. Applying this type of analysis can strengthen both the industrial and export potential of regions.

The main limitation of the analysis is the reliance on 2019 data, which does not reflect subsequent changes caused by the pandemic and sanction pressures. This reduces the relevance of the conclusions for the current situation but provides a stable basis for comparison. Furthermore, restricted access to official customs statistics after 2022 complicates the updating of calculations. Therefore, the results should be regarded as a reference point for strategic planning, requiring further verification using new datasets.

To justify the proposed hypothesis, a sequence of steps was developed to assess the structure of industry and the export basket of industrial regions (Table 1).

Table 1. Stages of assessing foreign trade activity in industrial regions.

1.	Potential of industrial regions in high-tech production
	Identification of industrial regions by calculating the arithmetic mean of two localization coefficients: (a) share of manufacturing in gross value added and (b) employment in manufacturing, both relative to the national average. A polygon of 42 regions was formed where the localization coefficient is greater than 1 (first selection criterion). Grouping of manufacturing and extractive industries into high- and medium-high-tech (HMT), medium-low-tech (MLT), and low-tech (LT) categories (Danilova & Nesytykh, 2023). Identification of Russian regions with localization of HMT industries. The second criterion is the high-tech localization coefficient (HLCR), calculated as the ratio of the share of shipped HMT products in the region to the national average. This yielded 32 regions for further analysis. Ranking of these regions into "leader regions" and "base regions" using the relative concentration coefficient (RCC-HMT), defined as the share of HMT products in the region's shipped output compared to their "uniform share" in national industry. The "uniform share" assumes all regions participate in post-industrial development, overcoming the minimum threshold: $d_n = \frac{100\ \%}{85\ regions\ (as\ of\ 2019)}$ =1,18 % (F1) Leaders: RCC-HMT ≥ 1, HLCR ≥ 1. Base regions: RCC-HMT ≤ 1, HLCR ≥ 1.
2.	Export potential of industrial regions
	Analysis of the value structure of exports depending on the technological classification of different types of economic activity. Assessment of the revealed comparative advantages (RCA) of export product positions, calculated as the ratio of the share of product i in a region's exports to the share of product i in Russia's total exports (a comparative advantage for product i exists when RCA > 1). Categorization of export flows by level of economic complexity, based on the Atlas of Economic Complexity ranking of the global product space (PCI Index). Four categories are distinguished: P1 – the most technologically advanced products (top quartile of positions evaluated), requiring knowledge-intensive competencies; P4 – raw materials and products with a low degree of processing; To ensure the principle of categorizing the entire product nomenclature and "equal filling" of groups, intermediate categories P2 and P3 were introduced. Comprehensive characterization of the structure of regional exports: the number of high-complexity products (category P1) with economic advantages, considering the global structure (if the share of a product in a region's exports is greater than its share in Russia's exports and at the same time Russia's share is greater than its share in global exports – both Russia and the region have advantages) and advantages relative to the structure of Russia's exports (if the share of a product in a region's exports is greater than its share in Russia's exports – advantage at the national level).
3	Typology of transformational variants of export activity in industrial regions
	Criteria introduced: а) share of high economic complexity products (P1) in the export structure of a region (above/below the median value of the sample); б) degree of concentration/diversification of P1 export products (threshold value of the Herfindahl–Hirschman Index, HHI = 1800): $HHI = \sum {d_i^{p_j^1}}^2$ (F2) where: – share of product i of category P1 in the export basket of region j. Differentiation of variants and positioning of prospects for regional transformation activity: 1) Open orientation – share of P1 above the median value and high concentration of product flow (HHI > 1800); "Fragmented-open" orientation – share of complex products P1 above the median, with diversified product flow (HHI ≤ 1800); 3) Local development – share of P1 products below the median value.

Note: The HHI = 1800 threshold is adopted by analogy with OECD and European Commission studies, where this level reflects the transition from a diversified to a concentrated market structure.

RESULTS AND DISCUSSION

The heterogeneity in the scale and level of industrial development, as well as the diversity of sectoral structures by technological intensity, determined the expediency of distinguishing subjects of the Russian Federation and identifying regions localized in high-tech and medium-high-tech industries (32 subjects). These were further classified into "leader regions," which differ not only by localization but also by production concentration, and "base regions," which possess only localization advantages. A general characterization of the industry in these regions and their groups, in terms of technological structure, production, and export, is presented in Table 2.

Table 2. Parameters of regional industry and exports.

Regions	Structure of shipped industrial products by technological intensity (HMT/MLT/LT), concentration and localization coefficients				Structure of exports by technological intensity (HMT/MLT/LT), %
	$D_{i,RF}$, %	RCC-HMT	D_i, %	HLCR	
Leader regions					
Average (16 regions)	3,1/12,0/1,3	2,64	34,9/ 35,4/ 29,8	1,79	45,1/ 21,6/ 33,4
Moscow Oblast, Republic of Tatarstan, Samara Oblast, Nizhny Novgorod Oblast, Kaluga Oblast, Perm Krai, Republic of Bashkortostan, Sverdlovsk Oblast, Leningrad Oblast, Yaroslavl Oblast, Tula Oblast, Saratov Oblast, Ulyanovsk Oblast, Udmurt Republic, Voronezh Oblast, Vologda Oblast					
Base regions					
Average	0,6/ 0,2/ 0,3	0,55	35,4/ 23,6/ 41,0	1,82	42,7/ 18,1/ 39,3
Vladimir Oblast, Tver Oblast, Chuvash Republic, Kirov Oblast, Ryazan Oblast, Novgorod Oblast, Bryansk Oblast, Altai Krai, Republic of Mordovia, Smolensk Oblast, Penza Oblast, Kurgan Oblast, Republic of Mari El, Tambov Oblast, Oryol Oblast, Pskov Oblast					

Comparative analysis of the sectoral structure of industry and exports confirms, on the one hand, the presence of potential for producing goods of high-tech types of activity, and, on the other, the differing contributions of regions to Russia's aggregate output. The primary role belongs to the leader regions: overall, their contribution to Russia's high-tech output is 49.7% (base regions—10.3%); moreover, the shares of Moscow Oblast, Samara Oblast, Nizhny Novgorod Oblast, Kaluga Oblast, and the Republic of Tatarstan each exceed 4%. The average value for the group of leaders is 3.1%, while for the base group it is much lower—0.64%, which differentiates their positions in enhancing the industrial self-sufficiency of Russia's economy. Regions with a high localization of high-tech output (over 40%) are few and represent the first line in strengthening Russia's technological sovereignty: Kaluga, Samara, Saratov, Yaroslavl, Ulyanovsk, Tver, Kirov, Kurgan, Novgorod Oblasts, and the Chuvash Republic.

The technological intensity of industry and the presence of production competencies in the analyzed regions are confirmed by the technological structure of exports: in 13 out of 32 regions, high-tech exports account for more than 50% of the region's exports (in Saratov, Yaroslavl, Ulyanovsk Oblasts and the Chuvash Republic such products also dominate total industrial output). Regions of different scales possess substantial industrial potential which, on the one hand, forms a territorial zone of high-tech industrial sectors and, on the other, determines the need to filter export product specializations for selective support of competitive industrial products.

To substantiate promising regional export directions, the authors identified product positions in which each federal subject has comparative advantages, implying the availability of resources, production capacities, etc., that ensure regional specialization. At the same time, it was taken into account that the resulting data reflect the established situation, whereas systemic constraints and the shift to a strategy of industrial sovereignty presuppose the production and export of products that are complex by global market standards.

One of the indicators of quality and a guide for filtering export specialization directions is the level of economic complexity of regional goods; in this regard, the Atlas of Economic Complexity ranking—specifically, the Product Complexity Index (PCI) was used: it included data on 971 HS product positions at the time of analysis. The set of exported goods was divided into four complexity categories; the subsequent analysis focuses on high-complexity goods, namely product positions of category P1 in the authors' approach. Quantitative values corresponding to high complexity—the first quartile (range 2.582–0.799)—include: machining centers; machines for processing using laser, light or photon beams, ultrasonic or plasma-arc processes; halides; solid-state non-volatile memory devices; smart cards; etc. "Complex exports" and "flows of high-complexity goods" are used as synonyms to emphasize the first-quartile (P1) category. Regional exports by typological groups are presented in **Table 3.**

Table 3. Characteristics of regional exports of high economic complexity products (fragment).

No	Category P1 Regions	Export structure: number, share in value, concentration						Number of products with RCA across all complexity categories
		N	Economic advantages of the region					
			vs. Russia's export structure			vs. world export structure		
					$HH_{IP}1$			
Leader regions								
	Average value	166,3	63,4	22,9	2615,6	1,75	12,8	214

Base regions								
	Average value	122,4	62,6	23,9	2535,8	0,75	8,0	208

Note: authors' calculations; N – diversity of P1 goods (number of product positions); RCA – revealed comparative advantages, K_(i RF)^P1 –K_(i W)^P1 – number of P1 positions with RCA relative to Russia's/world export structures;;d_(i RF)^P1, D_(i W)^P1 – share of P1 goods in the value of the region's exports; share of P1 goods for which the region simultaneously has advantages relative to the world export structure (if D_(i W)^P1 >, while K_(i W)^P1 =0 this means the product is exported but the region has no revealed comparative advantages); HHIP1 – concentration index for P1 goods.

The export structures of the analyzed regions are characterized by diversity in high-complexity product nomenclature, with a quantitative range of 74–241; at the same time, each region specializes in specific product positions in which it has economic advantages: their number is smaller (12–190) (maximum values in Moscow Oblast are 241 and 190). High economic-complexity goods constitute one-fifth of exports in both the leader and base groups; in the Udmurt Republic, and in Ulyanovsk and Kurgan Oblasts, such products account for more than 50%. Across the 32 regions, the nomenclature of supplies for which the region has comparative advantages of varying complexity levels reaches a maximum of 720 positions.

Flows of high-complexity goods have varying degrees of concentration, which significantly affect the stability of positions in the world/international market (export scale and capacity of the specialized product segment). Regions with high concentration of supplies in the P1 complexity category include Volgograd, Sverdlovsk, Tula, and Yaroslavl Oblasts; moreover, in two regions both the export share and concentration index reach maximum values: Udmurt Republic (76.2% and 4781.3, respectively) and Ulyanovsk Oblast (84.3% and 8466.3).

The results of localizing regional export specializations for which Russia has economic advantages relative to the world export structure are noteworthy. The authors compiled a matrix of product positions in Russia's export basket (1265 nomenclature items at the time of analysis) and identified 157 such goods of varying economic complexity, accounting for 86.98% of Russia's export value. There are few high-complexity positions with advantages at the global level: the maximum is in Moscow and Nizhny Novgorod Oblasts (5 positions each), yet 22 out of 32 regions have such unique goods. This confirms the feasibility and validity of defining a long-term goal (expanding production and Russia's niche) and medium-term guidelines focused on concentrating the output and supply of high-complexity products—both for transforming trade and simultaneously increasing industrial technological intensity.

In accordance with export quality indicators (share of high-complexity goods in exports and concentration level) (Table 4, Figure 1), the subjects of the Russian Federation were classified and the following situations identified: (1) regions with high potential for maintaining openness, revealed economic advantages, and high concentration of exports of complex high-tech goods (they supply the domestic market and are capable of exporting, and under sanctions can serve as platforms for high-tech production); (2) regions with the prospect of fragmented openness—broad output but an export basket distributed across many directions without strong specialization segments; (3) local development—low share of complex goods in exports.

Table 4. Classification of regions and filtering of export activity directions.

<table>
<tr><td colspan="2" rowspan="2">Export of category P1
Maintaining openness of foreign-economic relations</td><td colspan="2">Diversification/concentration of exports</td></tr>
<tr><td>Course toward fragmented openness</td><td></td></tr>
<tr><td rowspan="3">Share in export value above/ below the sample median, %</td><td>>19,9%</td><td>HHI≤1800 – 7 regions: Vladimir, Samara, Oryol, Moscow, Tver, Nizhny Novgorod Oblasts, Chuvash Republic. Group averages: share – 26.1%; concentration index – 1008,1.</td><td>HHI>1800 – 9 regions: Ulyanovsk, Kurgan, Tula, Saratov, Sverdlovsk, Ryazan, Bryansk Oblasts, Udmurt Republic, Republic of Mordovia. Group averages: share – 46.8%; concentration index– 4823,4.</td></tr>
<tr><td colspan="3">Local development</td></tr>
<tr><td>≤19,9 %</td><td colspan="2">14 regions – HHI>1800: Novgorod, Vologda, Yaroslavl Oblasts, Altai Krai; HHI≤1800: Republic of Bashkortostan, Perm Krai; Kirov, Pskov, Voronezh, Tambov, Kaluga, Smolensk, Penza Oblasts, Republic of Tatarstan. Group averages: share – 9.1%; concentration index– 1464,56</td></tr>
</table>

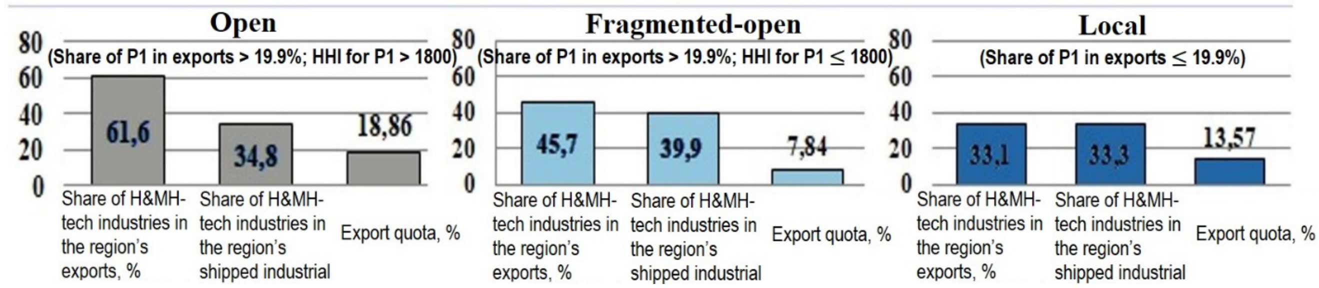

Fig 2. Variants of regional export activity directions.

It is notable that regions with the potential for an openness strategy (O)—a high share of complex goods and their concentration (46.8% and 4823.4, respectively)—are the spearhead of export transformation, as confirmed by the high-tech export quota (18.86%) and the average annual GRP growth rate (2019–2023) of 2.7% during a phase of active external constraints, as highlighted by the charts on the map. Regions with the prospect of a fragmented-open (F-O) option have a more diverse export basket but a lower starting potential—the high-tech export quota is 7.84%. It can be noted that the spatial concentration of regions (Figure 2) implies conditions favorable for restructuring foreign-economic activity (skilled personnel, high transport accessibility, territorial location conducive to production cooperation, the ability to form not only simple but also complex industries). This geography is confirmed by other researchers using different methodological approaches (Medvedkov et al., 2024).

The calculations show that leader regions, both with open and fragmented-open orientations, possess a significant pool of export goods and internal resources and therefore are a strategic priority for Russia as a whole, whereas for base regions, given their smaller scale and resources, it is advisable to concentrate on selected promising specializations (Figure 3, circle size indicates the region's share in Russia's P1 exports). Regions of the local-type development (L) display a low share of exports of high-complexity goods—9.1%.

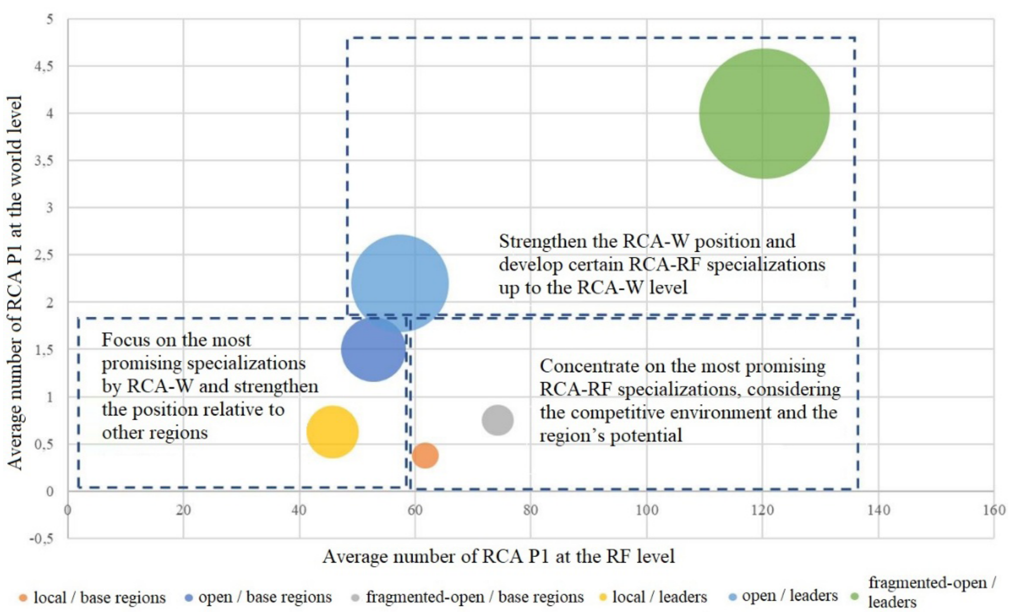

Fig 3. Comparative advantages of exports: alignment of region types (l—leaders, b—base) and development orientations (O, F-O, L).

It should be noted that the need for export transformation is defined in the new Spatial Development Strategy to 2036, which requires adjustments to regional strategic planning documents. The Strategy identifies as a priority the realization of export potential, expansion of export offerings, acquisition of new export specializations, and advancement in the global economic system. At the same time, the Strategy emphasizes a shift from a frontal advance across a broad spectrum of science-and-technology challenges to the prioritization of limited resources in selected directions.

A review of the socio-economic development strategies of the analyzed regions led to the conclusion that updates are lagging and that there is a need to specify the goals and objectives of transforming foreign trade. In accordance with the proposed criteria and classified situations, it is advisable to focus on the specific features of transformation directions in regions with high potential for maintaining openness (the goals and measures of industrial policy must be aligned) and in regions with fragmented-open development (emphasis on industrial policy in the high-tech segment of industries), as presented in Table 5.

Table 5. Fragment of transformational directions of activities of regional authorities in the strategic development of regional exports.

Direction of maintaining openness of foreign trade: policy alignment	
Goals and measures for industrial development	Goals and measures for export development
Diversification of the structure and technological complication of industrial sectors, expansion of the complex product portfolio, stimulation of strategic specializations competitive on the world market. Tasks: – creation of a catalog of complex high-tech products with concentrated exports; development and application of a regional diagnostic-maps tool; – concentration of limited resources on the development of strategic industries; prioritization of their support, inclusion in state programs and regional projects; – expansion of new high-tech production facilities to increase the capacity of high-complexity exports; – creation of a new type of technological clusters, a closed cycle of high-complexity industries, renewal of both the product and technological assortment of promising export-oriented industries.	Development of the segment of “new” complex high-tech exports of the region’s industrial products. Tasks: – formation of sectoral registers of exporters according to the criteria of product complexity on the world market, ranking of their readiness, advantages, possibilities for expanding supplies, and necessary support measures; – creation of a database of exporters in terms of sectoral orientation; complexity of high-tech products; geography of supplies; – support for expansion into foreign markets of higher stages of processing, assistance in integration into international production chains; – program-based state support for increasing export competitiveness on the basis of reimbursing part of the costs of producing and transporting high-tech products, etc.; – development of export infrastructure
Course toward fragmented openness of the region in export activity	
Delineation of industrial policy into two segments based on two criteria: the level of economic and technological development of the type of activity and the sectoral quota of complex products for export. Highly developed types of activity include high-tech industries with exports of complex products and the potential to maintain a position on the world market. Base industries are traditional for the region, with a capacious interregional market and oriented toward domestic needs of the country, with weak export potential. Tasks for development: a) for base types of activity – strengthening sectoral diversification, raising the technological level, renovating production sites, creating specialized industrial parks, developing cooperative links between base industries and high-tech ones; b) for highly developed ones – expanding new high-tech production capable of increasing capacities for complex products, integration-based development under cluster policy, access to support measures and instruments for promoting the region in foreign markets, which together should ensure a stable flow of industrial exports	

Such directions imply adjustments to regional documents—either inclusion, as a component, of new high-complexity product positions in the Strategy of Socio-Economic Development (the block “Main directions for the development of interregional and foreign-economic relations”) in connection with the adoption of Export Standards, or the development of independent strategies for the development of foreign-economic activity. For example, the “Strategy for the Development of International and Foreign-Economic Relations of Sverdlovsk Oblast for the Period up to 2035”, which focuses on trends toward the sixth technological paradigm, increasing high-tech goods demanded on world markets, and a new “commodity mass” of exports. In this regard, the strategic tool developed by the authors in the format of an analytical map with detailed potential product positions will contribute to enhancing the substantiation of regional export-support measures from the standpoint of selecting product priorities. As an example, information for Sverdlovsk Oblast is systematized in Table 6.

Table 6. Diagnostic map of the region (example of Sverdlovsk Oblast).

Production and export potential		
Industry	Exports	
Share of high-tech products in the region’s shipped output—58.0%; share in Russia’s production of such products—3.3%	Number of goods with RCA at both RF and world levels—2 (12.7% of the region’s exports)	
Share of high-tech exports—28.7%	Number of P1 RCA positions—79	
Openness strategy: concentration coefficient P1—3526.6; share in the region’s exports—21.2%.		
Promising specializations of high economic complexity (fragment)		
Types of economic activity	Complexity level of product positions	Share in Russia’s exports of the product positions (%)
Manufacture of chemicals	0,893-1,697	16,5-30,7

Manufacture of machinery and equipment	0,850-1,124	20,0-71,9
Manufacture of computers, electronic and optical products	0,967-1,918	32,4-26,8

Application of the diagnostic map makes it possible to identify transformation directions: strengthening the region's positions for goods with advantages on the world market (2 strong positions), and developing a roadmap to stimulate enterprises specializing in products of high economic complexity (grants, targeted and export support, etc.).

CONCLUSIONS

Under sanctions constraints, the regions of the Russian Federation remain involved in international trade, which makes it relevant to develop strategies for transforming foreign-economic activity. The regions differ in the scale and technological level of industry and in their product specializations.

The scientific novelty of the study lies in identifying the directions of commodity flows of the federal subjects, justifying the selection criteria and outlining strategic benchmarks, namely: categorizing products by the level of economic complexity and targeting the top quartile of complex goods according to the Product Complexity Index of the global product market; justifying the conditions for producing competitive goods (the presence of a high-tech sector of the economy, industrial output and exports, and concentrated commodity flows); and substantiating different potential strategies for transforming foreign trade activity. The combination of regional parameters—Russia's share in total exports of high-complexity goods, the presence of comparative advantages in product positions within the global product space and at the RF level, and the scale of the economy—together creates a set of circumstances that ensures the capacity of export flows and the formation of a stable niche in the world market.

Categorizing exports with regard to the global economic-complexity ranking made it possible to highlight potential transformation trajectories with varying degrees of intensity: a course toward maintaining openness, fragmented openness, and local participation in export activity. The presence of the necessary conditions (a substantial high-tech segment in regional industrial specializations) and the sufficiency of potential (the presence and concentration of a high-complexity export flow) are substantiated. The applied value of the study consists in developing diagnostic maps (shown using Sverdlovsk Oblast as an example) that include indicators of the production and export of goods of high economic complexity and promising HS positions under the EAEU, which ensures the soundness of measures to restructure foreign trade and to strengthen the technological competencies of regions in the interests of developing the industrial sovereignty of the Russian Federation.

The research was funded by the Russian Science Foundation and Chelyabinsk Region No. 25-18-20044, https://rscf.ru/en/project/25-18-20044/.

REFERENCES

Afanasyev, M. Yu., & Gusev, A. A. (2024). Situational modeling of regional development trajectories based on the concept of economic complexity. ***Regional Economy and Management: Electronic Scientific Journal, 2***(78), 1-13. https://doi.org/10.24412/1999-2645-2024-278-10

Akberdina, V. V., & Potaptseva, E. V. (2023). Ensuring the technological sovereignty of the state: the contribution of regions, in: Round table "Technological sovereignty: Experience of regional policy in leading regions". https://doi.org/10.13140/RG.2.2.31420.62080

Byvshev, V. I., Panteleeva, A. A., & Pisarev, I. V. (2024). Differentiation of the constituent entities of the Russian Federation for the implementation of regional scientific, technological and innovation policy. ***Economy of Regions, 20***(3), 702-717. https://doi.org/10.17059/ekon.reg.2024-3-7

Danilova, I. V., & Nesytykh, K. Yu. (2023). Stratification of the space of industrial regions: General and special development of manufacturing industry. ***Bulletin of the South Ural State University. Series: Economics and Management, 17***(2), 7-23. https://doi.org/10.14529/em230201

Dementiev, V. E. (2023). Technological sovereignty and priorities of localization of production. ***Terra Economicus, 21***(1), 6-18. http://dx.doi.org/10.18522/2073-6606-2023-21-1-6-18

Janger, J. (2024). Innovation, industrial and trade policies for technological sovereignty. FIW - Policy Brief, No. 61. FIW - Research Centre International Economics. https://www.fiw.ac.at/publications/fiw-pb-61-technological-sovereignty/

Letta, E. (2024). Much more than a market – Speed, security, solidarity: Empowering the single market to deliver a sustainable future and prosperity for all EU citizens. https://www.consilium.europa.eu/media/ny3j24sm/much-more-than-a-market-report-by-enrico-letta.pdf

Luo, Y. (2022). Illusions of techno-nationalism. ***Journal of International Business Studies, 53***(3), 550-567. https://doi.org/10.1057/s41267-021-00468-5

March, C., & Schieferdecker, I. (2023). Technological sovereignty as ability, not autarky***. International Studies Review, 25***(2). https://doi.org/10.1093/isr/viad012

Mariotti, S. (2024). "Win-lose" globalization and the weaponization of economic policies by nation-states. ***Critical Perspectives on International Business, 20***(5), 638-659. https://doi.org/10.1108/cpoib-09-2023-0089

Mariotti, S. (2025). "Open strategic autonomy" as an industrial policy compass for the EU competitiveness and growth: The good, the bad, or the ugly? ***Journal of Industrial and Business Economics, 52***(1), 1-26. https://doi.org/10.1007/s40812-024-00327-y

Medvedkov, M. Yu., Mikheeva, E. A., & Khalilyulin, I. N. (2024). The Fourth Industrial Revolution, European Union competitiveness and future of international trade. ***St. Petersburg University Journal of Economic Studies, 40***(2), 191-211. https://doi.org/10.21638/spbu05.2024.203

Minakir, P. A. (2023). The foreign-trade factor of the force-majeure economy: A spatial maneuver. ***Spatial Economics, 19***(1), 7-19. http://dx.doi.org/10.14530/se.2023.1.007-019

Shubin, I. A. (2021). Correlation between economic complexity and economic development in different types of Russian regions. ***Journal of the New Economic Association, 3***(51), 144-161. https://doi.org/10.31737/2221-2264-2021-51-3-7

Tagliapietra, S., & Veugelers, R. (Eds.). (2023). Sparking Europe's new industrial revolution. A policy for net zero, growth and resilience. Bruegel.

Ushkalova, D. I. (2022). Russia's foreign trade under sanction pressure. ***Journal of the New Economic Association, 3***(55), 218-226. http://dx.doi.org/10.31737/2221-2264-2022-55-3-14

Van den Abeele, E. (2021). Towards a new paradigm in open strategic autonomy? ETUI Research Paper, Working Paper, No. 2021.03. ETUI aisbl.

Volkova, N. N., & Romanyuk, E. I. (2024). Contribution of regions to the technological sovereignty of the country: Using the possibilities of statistical analysis. ***Bulletin of the Institute of Economics of the Russian Academy of Sciences, 6,*** 93-115. https://cyberleninka.ru/article/n/vklad-regionov-v-tehnologicheskiy-suverenitet-strany-ispolzovanie-vozmozhnostey-statisticheskogo-analiza/pdf

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

Authors' Contribution (CRediT Taxonomy)

Author	Roles
Irina Danilova	Conceptualization, Funding acquisition, Project administration, Writing – original draft, Supervision.
Irina Mikhailova	Methodology, Formal analysis, Validation.
Evgeny Stepanov	Data curation, Software, Visualization.
Ksenia Nesytyh	Investigation, Resources, Writing – review & editing.