

Resilience of regional economic systems: from methodology to practice

Resiliência dos sistemas econômicos regionais: da metodologia à prática

Resiliencia de los sistemas económicos regionales: de la metodología a la práctica

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Marat Safiullin

Kazan (Volga Region) Federal University, Russian Federation

Center for Advanced Economic Research, Academy of Sciences of the Republic of Tatarstan, Kazan, Russia

<https://orcid.org/0000-0003-3708-8184>

Leonid Elshin

Center for Strategic Assessments and Forecasts, Kazan (Volga Region) Federal University, Russian Federation. Research, Center for Advanced Economic Research, Academy of Sciences of the Republic of Tatarstan, Russian Federation. TISBI University of Management, Russian Federation

<https://orcid.org/0000-0002-0763-6453>

Azat Sharapov

Volga Region State University of Physical Education, Sports, and Tourism, Russian Federation

<https://orcid.org/0000-0001-8489-183X>

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Abstract

Foreign economic turbulence, increased risks of macroeconomic instability, different resilience potential of regions and industries to crisis manifestations, etc. stipulate the need to offer appropriate concepts and models of regional strategic development with due regard to the adjusting institutional environment and mechanisms that shape the dynamics and characteristics of modern economic growth. This study develops concepts and tools for empirically assessing the resilience of regional economic systems. The Volga Federal District (Russia) constituent entities are the research object. The basis of the original concept is a 3D model that assumes the need to study resilience in the context of three key components. The first characterizes the readiness of the research object for systemic transformations. The other two components (export dependence and import dependence), combined into an aggregated indicator, form the potential for assessing the vulnerability of regions during the transformation of foreign economic relations. The result is the assessment of the resilience of regional economic systems, which lays the basis for developing solutions in regional policy in the context of systemic transformations expressed in sanctions against the Russian economy.

Keywords: resilience, performance resilience, data decomposition, research methodology, systemic transformations.

Resumo

Turbulência econômica estrangeira, riscos aumentados de instabilidade macroeconômica, diferentes potenciais de resiliência de regiões e indústrias a manifestações de crise, etc. estipulam a necessidade de oferecer conceitos e modelos apropriados de desenvolvimento estratégico regional com a devida consideração ao ambiente institucional de ajuste e mecanismos que moldam a dinâmica e as características do crescimento econômico moderno. Este estudo desenvolve conceitos e ferramentas para avaliar empiricamente a resiliência de sistemas econômicos regionais. As entidades constituintes do Distrito Federal do Volga (Rússia) são o objeto de pesquisa. A base do conceito original é um modelo 3D que assume a necessidade de estudar a resiliência no contexto de três componentes principais. O primeiro caracteriza a prontidão do objeto de pesquisa para transformações sistêmicas. Os outros dois componentes (dependência de exportação e dependência de importação), combinados em um indicador agregado, formam o potencial para avaliar a vulnerabilidade das regiões durante a transformação das relações econômicas estrangeiras. O resultado é a avaliação da resiliência dos sistemas econômicos regionais, que estabelece a base para o desenvolvimento de soluções em política regional no contexto de transformações sistêmicas expressas em sanções contra a economia russa.

Palavras-chaves: resiliência, resiliência de desempenho, decomposição de dados, metodologia de pesquisa, transformações sistêmicas.

Resumen

La turbulencia económica externa, el aumento de los riesgos de inestabilidad macroeconómica, el diferente potencial de resiliencia de las regiones y las industrias ante las manifestaciones de crisis, etc., exigen la elaboración de conceptos y modelos adecuados de desarrollo estratégico regional, teniendo debidamente en cuenta el entorno institucional en proceso de ajuste y los mecanismos que configuran la dinámica y las características del crecimiento económico moderno. En este estudio se desarrollan conceptos y herramientas para evaluar empíricamente la resiliencia de los sistemas económicos regionales. El objeto de la investigación son las entidades constitutivas del Distrito Federal del Volga (Rusia). La base del concepto original es un modelo 3D que asume la necesidad de estudiar la resiliencia en el contexto de tres componentes clave. El primero caracteriza la preparación del objeto de investigación para las transformaciones sistémicas. Los otros dos componentes (dependencia de las exportaciones y dependencia de las importaciones), combinados en un indicador agregado, forman el potencial para evaluar la vulnerabilidad de las regiones durante la transformación de las relaciones económicas externas. El resultado es la evaluación de la resiliencia de los sistemas económicos regionales, que sienta las bases para desarrollar soluciones en la política regional en el contexto de las transformaciones sistémicas expresadas en sanciones contra la economía rusa.

Palabras clave: resiliencia, resiliencia de desempeño, descomposición de datos, metodología de investigación, transformaciones sistémicas.

1. INTRODUCTION

The ongoing changes in the world characterized by increased economic, political, and social turbulence initiate processes that deform classical mechanisms of economic development (Kashina et al., 2022). This phenomenon manifests at macro- and meso-levels and in specific sectors of economic activity, whose stability is at risk during periods of systemic transformation and geopolitical and geoeconomic upheaval (Alekseev et al., 2022). Economic systems adapt differently to destructive changes due to their diverse mechanisms of development and integration into the system of external economic relations. Studying these mechanisms of adaptation to ongoing institutional and time-serving shifts allows for identifying features and prospects for economic development in new institutional relations and determining the most effective directions for government regulation at macro- and meso-levels (Borodina et al., 2022; Vysotskaya et al., 2022; Kochetkov et al., 2023).

This agenda is particularly relevant for the Russian Federation, where regional

development significantly differs due to the spatial-sectoral organization of the economic structure and established economic connections, including transnational ones (Gafurov et al., 2015). In this context, studying the resilience and adaptation of regional industries to external factors and determining the parameters and prospects for sustainable regional development is an extremely demanded area in modern economic science (Eskerkanova et al., 2023). Since traditional economic models have limited manifestations under artificial exogenous impacts on regional and sectoral economic systems within the framework of sanctions against the national economy, there is a need to search for new approaches to improve the methodological base for studying regional economic growth (Kirillova et al., 2023). It is worth mentioning the direction associated with the development of diagnostic models for the prospects of sustainable regional economic development under new realities related to increasing external pressures in the form of sanction attacks (Bagratuni et al., 2023).

2. LITERATURE REVIEW

Organizing economic processes across regions and sectors and ensuring sustainable development for these systems are key priorities in the theory of regional economy. These issues are addressed in classic and contemporary works by scientists. The most prominent among them is Isard (1956), the founder of regional economic theory, who developed concepts for managing territories, industrial complexes, regional infrastructure, settlement systems, etc. Isard's scientific work has been extended by Friedman (1973), Richardson (1969) (urban agglomeration theory), Hoover and Giarratani (2020), and Krugman (1991) (interregional labor migration model).

Methodological approaches to empirically assessing the resilience of economic systems are contained in the works by Foster (2007), Hill (2008), Martin (2012), Fingleton (2012), and Lagravinese (2015), and others (Taleb, 2007).

Much of the research in this field focuses on assessing changes in key macroeconomic parameters, which reflect the volatility and responsiveness of economies to external shocks.

Zhikharevich (2020), Zubarevich (2020), Kazakov, Klimanov, and Mikhailova (2019), Kuznetsova (2023), Malkina (2022), and Pilipenko (2010) have also contributed to the

empirical assessment of the resilience of regional economic systems.

The review and systematization of approaches to the resilience of regional economies focus on evaluating and analyzing changes in macroeconomic indicators before and after shocks impact the economic system. We aim to measure the volatility of these indicators as a reflection of regional reaction and resilience to external disturbances. Commonly studied macroeconomic parameters include GRP growth rates, changes in investment in fixed capital, adjustments in indicators characterizing the development of regional labor markets, etc.

The study of regional resilience should be conducted through a comprehensive assessment rather than focusing on individual changes in macro parameters. Evaluating the resilience of regional economic systems is a multi-level, modular task that should be approached in an aggregated and synthesized form. This format is explored insufficiently and requires further methodological and theoretical development.

Our objective was to develop a concept and tools for empirically assessing the resilience of regional economic systems.

3. METHODS

We present a new methodological toolkit based on the research framework proposed by Foster (2007). We propose to study the multidimensional state (matrix) of regional resilience through a 3D measurement system: import dependence, export dependence, and performance resilience. Our research focus is stipulated by the emphasis on sanction shocks, which primarily target the restriction of imports and exports and the disruption of established international supply chains. These disruptions affect the operational business cycles of regional-sectoral complexes, determining the vulnerability of regional economic systems and their potential to withstand external disturbances.

We propose to implement the construction of a 3D matrix for the resilience of regional economic systems by intersecting the following measurement axes: import dependence (Res_{imp}), export dependence (Res_{exp}), and performance resilience (Res_{per}).

To specify the proposed conceptual approach, we need to detail the iterative sequence of calculations for the individual components of the aggregated regional resilience index

(ReSimp, ReSexp, ReSper).

3.1 Assessment of import and export dependence of regional economic systems (RES_{EXP})

Disturbances in foreign trade relations, particularly the restriction of imports and exports within established external markets, determine the vulnerability of regional development and regional resilience parameters. In this context, an important feature in studying the resilience of regional systems is examining the sensitivity of these processes to the localization of foreign trade relations as a result of sanctions against the national economy. A key methodological aspect of assessing and analyzing resilience is the evaluation of regional import and export dependence (Res_{exp}).

The methodological basis for assessing regional export dependence is the analysis of the share of its products exported to unfriendly countries in the total volume of GRP (1).

$$\text{Res exp} = \frac{\text{Volume of export into unfriendly countries}}{\text{GRP}} \quad (1)$$

The import dependence of regional economic systems is assessed in a similar manner (2).

$$\text{Res imp} = \frac{\text{Volume of import from unfriendly countries}}{\text{GRP}} \quad (2)$$

To unify the obtained values and compare them, with the subsequent integration of data into the 3D resilience model, all obtained estimates (indices) are standardized.

If the studied indicators belong to the category of stimulants, i.e., their higher values indicate an increase in the effectiveness of the studied object, formula (3) is used.

$$Z_i = \frac{X_i - \bar{X}_i}{\sigma_i} \quad (3)$$

where X_i is the actual value of the i indicator,

\bar{X}_i is the average value of the i indicator,

σ_i is the standard deviation.

If the indicator belongs to the category of a disincentive (its growth means a decrease in efficiency), it is advisable to use formula (4).

$$Z_i = \frac{\overline{X_i} - X_i}{\sigma_i} \quad (4)$$

To bring the indicators to a single scale (from 0 to 1) and to calculate the integral index, the normalized values of the indicators are transformed into a function of the standard normal integral distribution (5).

$$Z_i^{\text{norm}} = \frac{1}{\sqrt{2\pi}} e^{-\frac{z_i^2}{2}} \quad (5)$$

where Z_i is the normalized value of the indicator.

To determine the aggregate value of the vulnerability of a regional economic system from the level of its integration into international supply chains, the integral index Res_{vul} is determined based on an assessment of the geometric mean of the parameters characterizing the import and export dependence of the research object (6).

$$Res \text{ vulnerability} = \sqrt[2]{Resimp * Resexp} \quad (6)$$

3.2 Assessment of performance resilience

We propose to measure the direction of resilience for the parameter of performance resilience within the framework of the modernization of M.Yu. Malkina's (2020) approach. It is based on a comparison of prognostic macroeconomic parameters characterizing the socio-economic sustainability of regional development with the data formed during the acute phase of turbulence.

The ratio between the predicted value within the framework of the inertial dynamics of the process under study and the actual value of the analyzed parameter forms the basis for assessing this deviation and forming an idea of the stability of the process to the generation of macroeconomic shocks.

In a concentrated form, the regional resilience index in the direction of performance resilience is based on the following calculation algorithm (7).

$$Ri = \frac{\hat{y}}{y} - 1 \quad (7)$$

where Ri is the value of the i indicator participating in the construction of the aggregate value of the integral resilience index in the direction of performance resilience, \hat{y} is the predicted value of the index during the crisis period (the forecast is based on constructing an autoregressive function), y is the actual value of the index during the crisis.

We used the following parameters of the efficiency of the regional economic system recovery in assessing the integral resilience index in this direction: real accrued wages, population size, poverty level, and employment level. These indicators signal possible regional corrections in the population's quality of life. Performance resilience includes the parameters of regional budget sustainability. The indicator of surplus/deficit of the consolidated budget of the constituent entity of the Russian Federation should be analyzed.

This approach to measuring the performance resilience of the regional economic system corresponds to those used by Foster (2007), Zhikharevich, Klimanova, and Maracha (2020), Malkina (2022), and others.

The normalization (standardization) of the assessments forms the basis for determining the integral value of regional resilience in the direction of performance resilience according to the formula ($\sqrt[i]{Ri_{norm}}$).

3.3 Matrix assessment of regional/sectoral resilience

A crucial methodological stage in studying regional resilience is the construction of a matrix that distributes regional systems into four quadrants along two axes of measurement: vulnerability and performance resilience (Figure 1).

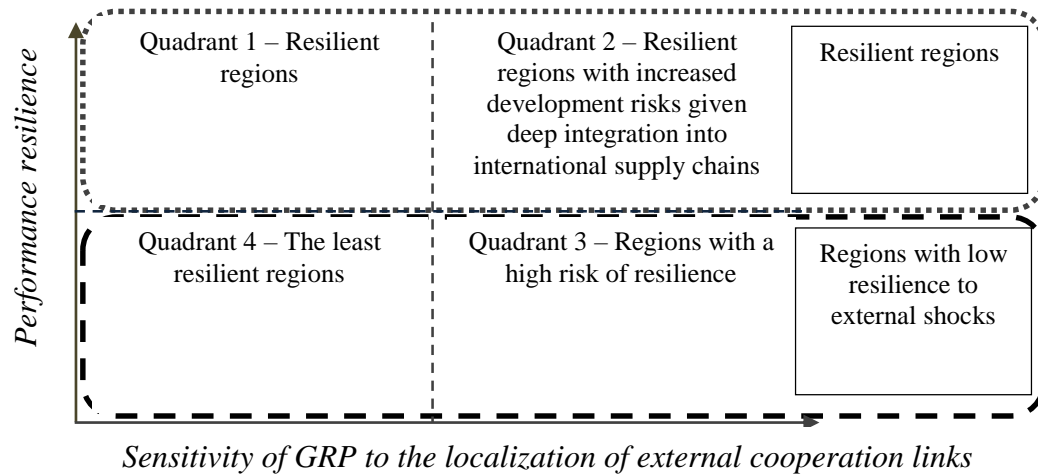


Figure 1. Concept of studying regional resilience according to the matrix of distribution of resilience parameters in the directions of vulnerability/performance resilience
Source: developed by the authors

- 1 Regions with a high level of resilience due to a low level of integration into international supply chains
- 2 Regions with a high level of integration into international supply chains and a high level of performance resilience
- 3 Regions with a relatively low level of foreign trade cooperation links and an unstable level of performance resilience
- 4 Regions with a high level of integration into international supply chains and a low level of performance resilience

Based on the possible synthesized assessments characterizing the resilience of regional economic systems, all studied entities are divided into four groups (Figure 1). The first group (Quadrant 1) includes regions with the best characteristics: low dependence on imports and exports with unfriendly countries and high performance resilience. Their high resilience is due to their low import and export dependence and effectively implemented government regulation measures.

The second group (Quadrant 2) includes regions characterized by high integration in international supply chains and high performance resilience. These regions can be called resilient. However, their vulnerability risks are high due to their extensive economic relations with unfriendly countries. The high vulnerability of industries to transnational cooperative ties creates an increased risk for their sustainable development in turbulent conditions.

The third group (Quadrant 4) includes regions characterized by weak resilience despite low levels of integration into international supply chains. These regions require urgent measures to enhance the quality of government planning and management.

Finally, regions in Quadrant 3 have a high dependence on imports and exports with unfriendly countries while demonstrating weak recovery levels under restricted foreign economic relations.

Depending on the quadrant a region falls into, mechanisms for government support and management of regional economic systems are determined to ensure the most effective adaptation to systemic transformations caused by sanctions against the national economy.

4. RESULTS

According to customs statistics, the foreign trade turnover of the Volga Federal District (Russia) amounted to 61 billion 499 million USD in 2021 and increased by 37% compared to 2020. Exports increased by 42.4% and amounted to 44 billion 245 million USD, and imports increased by 24.7% to 17 billion 254 million USD (Table 1 and Figure 2).

Table 1
Trade turnover of the Volga Federal District (million USD)

	2017				2021			
	Export	Import	Turnover	Balance	Export	Import	Turnover	Balance
Total	36,970.9	13,550.0	50,520.9	23,420.9	44,245.3	17,253.6	61,498.9	26,991.7
CIS countries	8,737.3	1,940.8	10,678.1	6,796.5	9,846.3	1,859.0	11,705.3	7,987.3
Non-CIS countries	28,233.6	11,609.2	39,842.8	16,624.5	34,399.0	15,394.6	49,793.7	19,004.4

Source: Tamozhennaya statistika Privolzhskogo tamozhennogo upravleniya

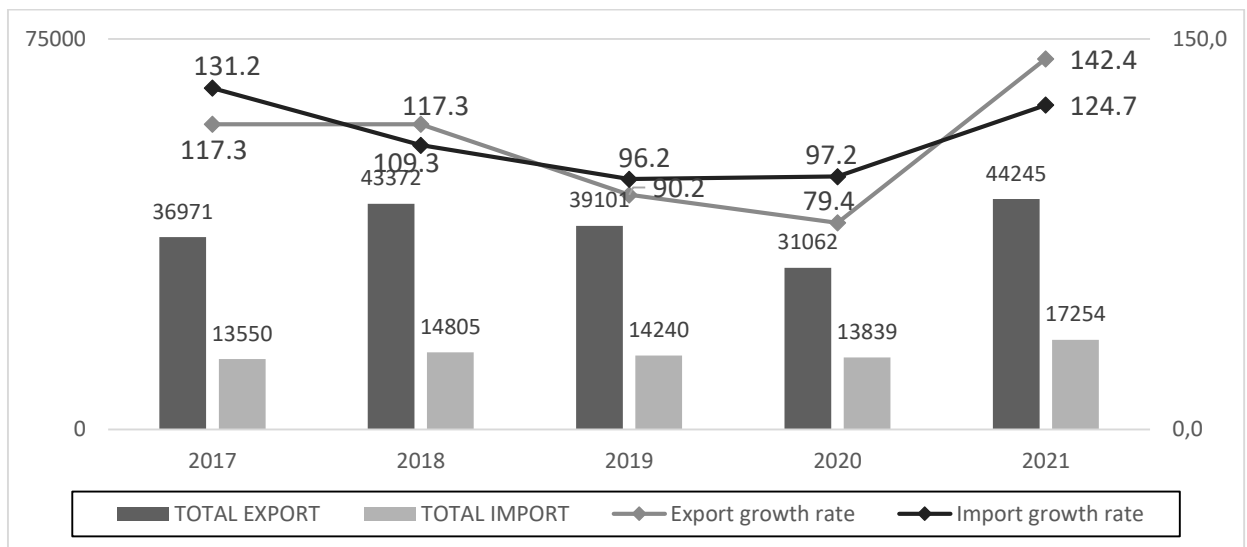


Figure 2. Dynamics of imports and exports of the Volga Federal District (million USD)
 Source: based on data from Tamozhennaya statistika Privolzhskogo tamozhennogo upravleniya

If we consider trade turnover with non-CIS countries, imports grew at a faster rate compared to exports. From 2017 to 2021, exports to these countries increased by 40%, while imports rose by 74% (Figure 3). However, the trade balance remains positive.

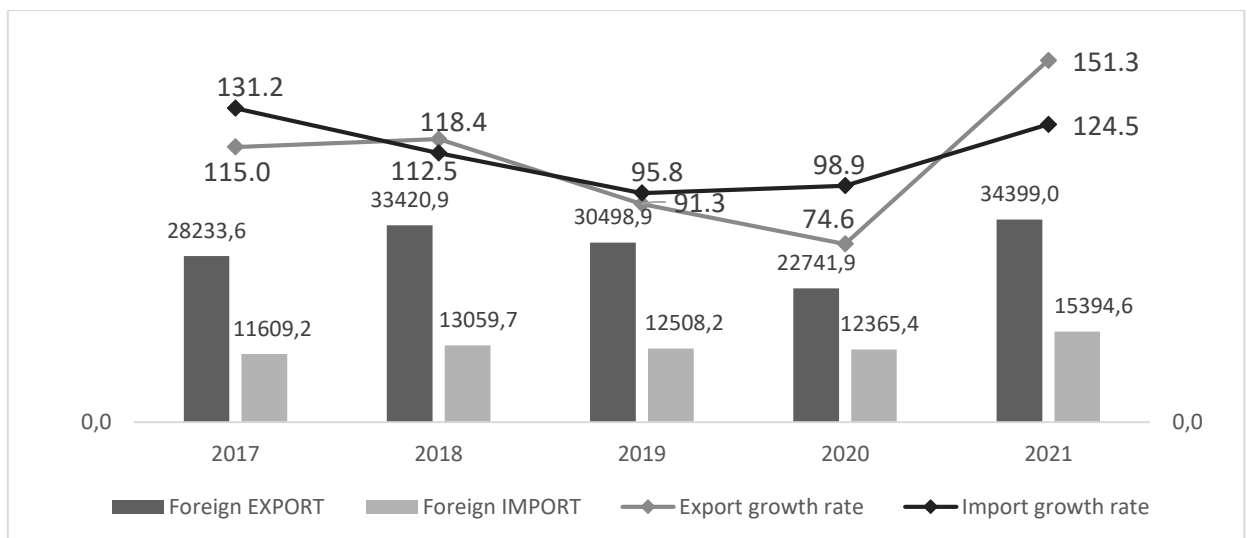


Figure 3. Dynamics of imports and exports of the Volga Federal District with non-CIS countries (million USD)

Source: based on data from Tamozhennaya statistika Privolzhskogo tamozhennogo upravleniya

In 2021, most imports to the Volga Federal District from non-CIS countries were concentrated in the Republic of Tatarstan, Nizhny Novgorod Region, and Samara Region, accounting for approximately 70% (Table 2). Regarding imports from CIS countries, the same regions and the Republic of Bashkortostan comprised about 65%.

Table 2
Structure of imports in the Volga Federal District by regions in 2021

	Share in imports from non-CIS countries, %	Share in imports from CIS countries, %
Imports	100	100
Republic of Tatarstan	33.3	18.5
Nizhny Novgorod Region	18.5	19.0
Samara Region	16.7	16.1
Saratov Region	5.7	4.1
Perm Territory	4.6	7.4
Republic of Bashkortostan	4.5	11.3
Ulyanovsk Region	4.4	2.5
Udmurt Republic	3.3	2.9
Kirov Region	2.7	2.2
Penza Region	1.9	3.5
Chuvash Republic	1.7	2.8
Orenburg Region	1.0	7.9
Republic of Mari El	0.8	0.6
Republic of Mordovia	0.8	1.3

Source: Tamozhennaya statistika Privolzhskogo tamozhennogo upravleniya

The share of exports in trade turnover with non-CIS countries amounted to 69.1% at the end of 2021 (compared to 70.9% in 2017). The share of imports increased over the period under review by 1.8% and amounted to 30.9% (Table 3)

Table 3
Structure of trade turnover of the Volga Federal District

	Share of exports in trade turnover, %		Share of imports in trade turnover, %	
	2017	2021	2017	2021
Total	73.2	71.9	26.8	28.1
CIS countries	81.8	84.1	18.2	15.9
Non-CIS countries	70.9	69.1	29.1	30.9

Source: Tamozhennaya statistika Privolzhskogo tamozhennogo upravleniya

The Republic of Tatarstan accounted for 36% of the total import volume and 42% of the total export volume with unfriendly countries. Thus, unfriendly countries comprise most of the trade turnover in Tatarstan: 65% of imports and 76% of exports. The balance of trade turnover of Tatarstan with unfriendly countries was positive, and exports exceeded imports by a factor of 2.6. The Orenburg Region was the least dependent on imports from unfriendly countries: 23.9% of imports (Figure 4).

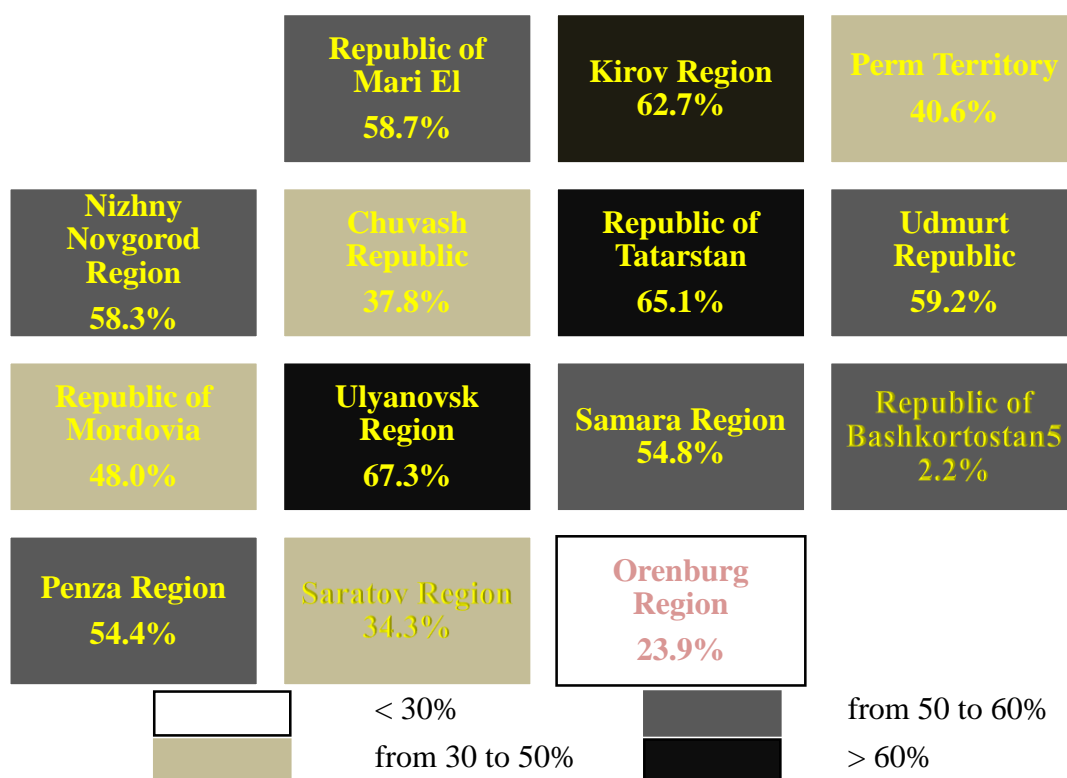


Figure 4. Share of unfriendly countries in imports of the Volga Federal District in 2021, %
Source: based on: Tamozhennaya statistika Privolzhskogo tamozhennogo upravleniya

The least dependent on exports from unfriendly countries were the Udmurt Republic, the Chuvash Republic, and the Saratov Region (18.2, 22.1, and 23.4% of the total exports, respectively) (Figure 5).

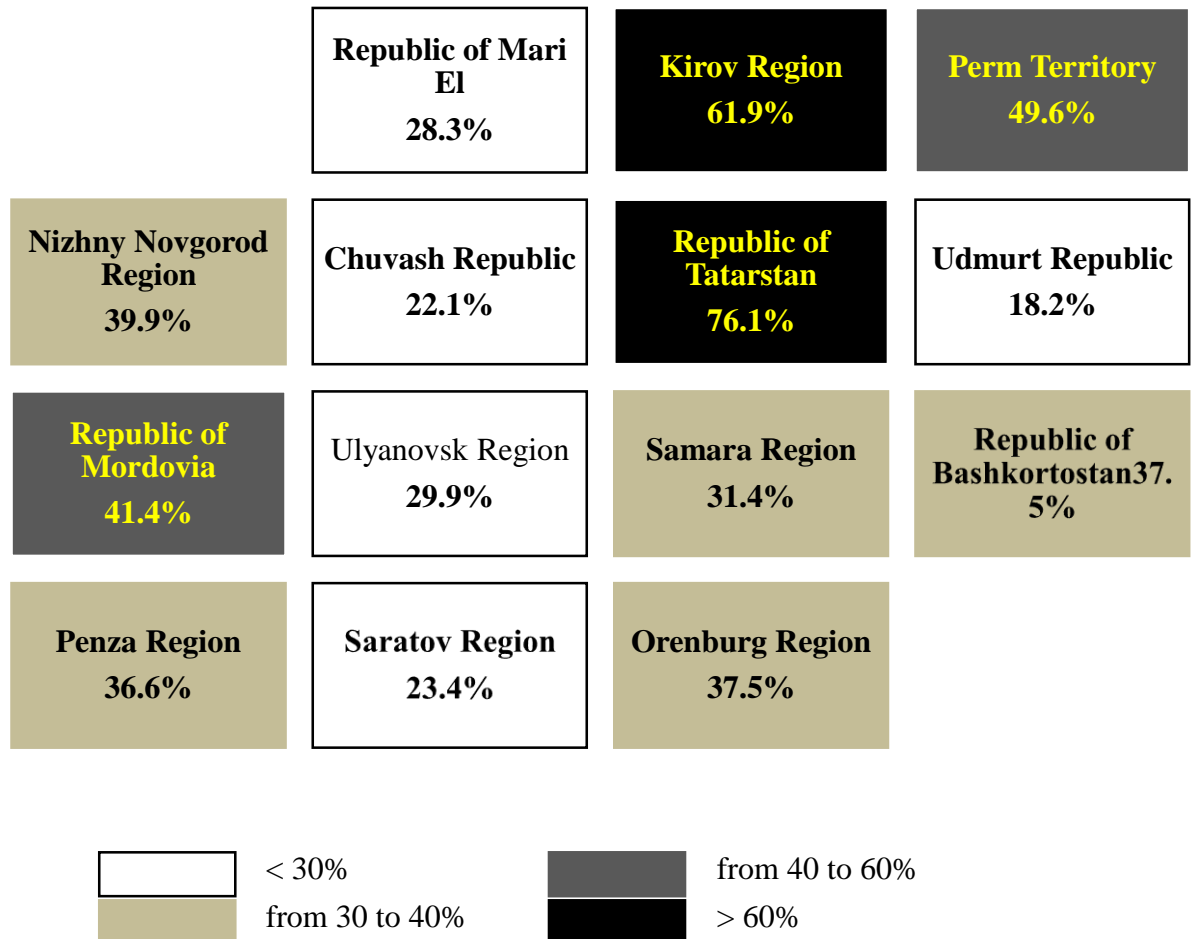


Figure 5. Share of unfriendly countries in exports of the Volga Federal District in 2021, %
 Source: based on data from Tamozhennaya statistika Privolzhskogo tamozhennogo upravleniya

Relying on the descriptive analysis of imports and exports in the Volga Federal District, Table 4 presents characteristics that show regional vulnerability related to imports from foreign (unfriendly) markets and exports to them.

Table 4

Assessing the vulnerability of the constituent entities of the Volga Federal District related to imports and exports with unfriendly countries

	Imports from unfriendly countries, million USD	Exports from unfriendly countries, million USD	GRP, million rubles	Share of imports from unfriendly countries in the GRP, %	Share of exports from unfriendly countries in the GRP, %
Volga Federal District	9,789.2	21,810.4	16,878,414.5	4.3	9.5
Republic of Tatarstan	3,560.5	9,183.3	3,454,700.0	7.6	19.6
Kirov Region	281.5	779.1	481,407.0	4.3	11.9
Perm Territory	343.4	3,941.5	1,740,525.3	1.5	16.7
Republic of Mordovia	70.6	155.4	298,023.1	1.7	3.8
Nizhny Novgorod Region	1,867.6	2,647	1,888,121.4	7.3	10.3
Republic of Bashkortostan	470.2	1,392	2,000,037.9	1.7	5.1
Orenburg Region	70.5	984.6	1,394,280.3	0.4	5.2
Penza Region	195.5	131.1	537,290.0	2.7	1.8
Samara Region	1,576	1,625	2,122,537.2	5.5	5.6
Ulyanovsk Region	490.4	175.2	498,806.3	7.2	2.6
Republic of Mari El	78.8	92	221,991.0	2.6	3.1
Saratov Region	328	528.4	1,005,800.9	2.4	3.9
Chuvash Republic	121.7	66.6	392,957.9	2.3	1.2
Udmurt Republic	334.6	109.3	841,936.2	2.9	1.0

Source: based on data from Tamozhennaya statistika Privolzhskogo tamozhennogo upravleniya, Regiony Rossii. Sotsialno-ekonomicheskie pokazateli, 2023

Following the proposed methodology, we normalized the assessments to unify the parametric data. The results of this iterative process are presented in Figure 6. The standardization involves bringing the dimensional indicators into the range from 0 to 1. The maximum value indicates a high level of vulnerability of the regional economic system to external cooperative ties with unfriendly countries.

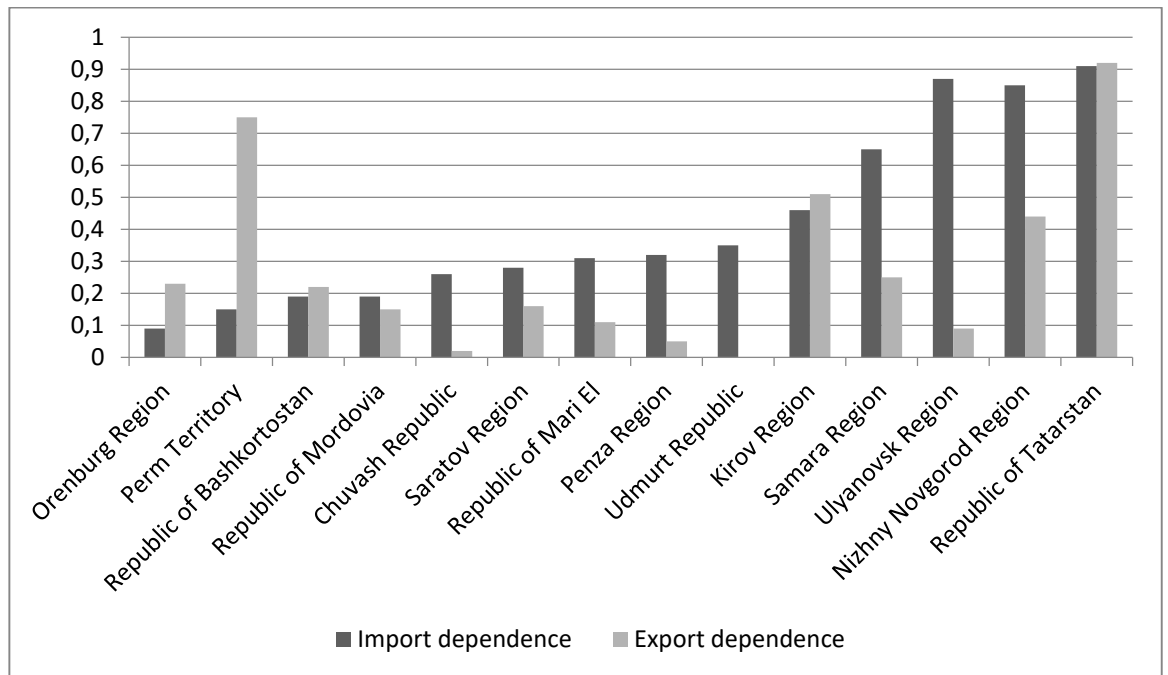


Figure 6. Normalized (standardized) values characterizing the level of import and export dependence of the regions of the Volga Federal District (as of 2021)

Source: calculated by the authors

The results of transforming the estimates into integral values according to the proposed methodological solutions are presented in Table 5 and Figure 7

Table 5
Values of the integral vulnerability index (I_{vul}) of the Volga Federal District

No.	Constituent entity	Integral vulnerability index (I_{vul})
	Republic of Tatarstan	0.91
	Nizhny Novgorod Region	0.61
	Kirov Region	0.48
	Samara Region	0.40
	Perm Territory	0.34
	Ulyanovsk Region	0.28
	Saratov Region	0.21
	Republic of Bashkortostan	0.21
	Republic of Mari El	0.19
	Republic of Mordovia	0.17
	Orenburg Region	0.14
	Penza Region	0.12
	Chuvash Republic	0.06
	Udmurt Republic	0.06

Source: calculated by the authors

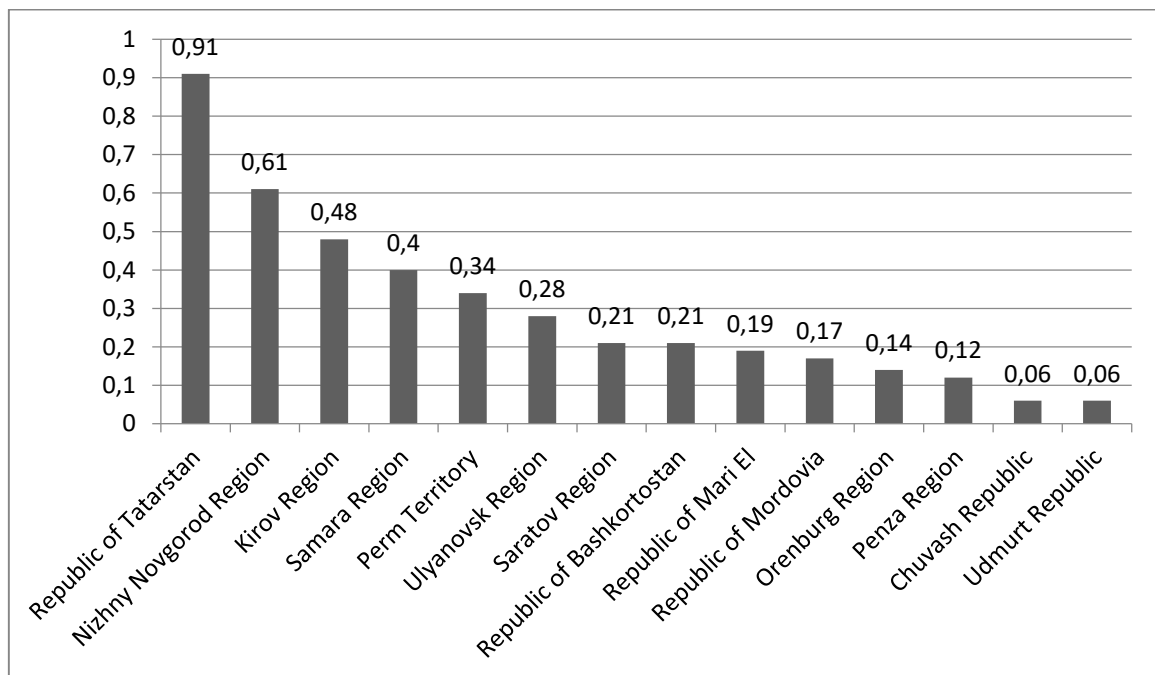


Figure 7. Values of the integral vulnerability index (I_{vul}) of the Volga Federal District
Source: calculated by the authors

At the second stage of the study, we applied the same methodological tools and assessed the second component of regional resilience, performance resilience.

Table 6 presents the assessments for the indicator of real accrued wages as a percentage of the corresponding period of the previous year.

Table 6

Indicators of resilience of the constituent entities of the Volga Federal District under 2022 sanctions (predicted and actual values). The analyzed resilience parameter is real accrued wages as a percentage of the corresponding period of the previous year

No.	Constituent entity	Predicted value (\hat{y})	Actual value (y), 2022	Value of private resilience index (Ri) ($\frac{\hat{y}}{y} - 1$)	Normalized value of the indicator (Ri_{norm})
1	Republic of Bashkortostan	103.0	100.8	-0.021	0.36
2	Republic of Mari El	101.6	100.4	-0.012	0.51
3	Republic of Mordovia	104.0	101.8	-0.021	0.36
4	Republic of Tatarstan	102.3	100.1	-0.021	0.36
5	Udmurt Republic	103.5	100.1	-0.033	0.17
6	Chuvash Republic	103.4	101.2	-0.021	0.36
7	Perm Territory	102.7	100.2	-0.024	0.32

8	Kirov Region	102.9	98.5	-0.043	0.00
9	Nizhny Novgorod Region	101.3	103.1	0.018	1.00
10	Orenburg Region	102.5	99	-0.034	0.15
11	Penza Region	101.7	100.2	-0.015	0.46
12	Samara Region	101.5	100.1	-0.014	0.48
13	Saratov Region	103.6	101	-0.025	0.30
14	Ulyanovsk Region	101.7		-0.016	0.44

Source: calculated by the authors based on the Federal State Statistics Service data Regiony Rossii. Sotsialno-ekonomicheskie pokazateli, 2023

Similar iterative actions were implemented for the other indicators involved in the integrated assessment of the aggregated parameter of the population’s quality of life (R_{ql}). The latter is one of two elements that determine the effectiveness of regional recovery (Table 7).

Table 7
Integral values (R_{ql}) of the index of the effectiveness of regional recovery in the Volga Federal District by the parameter of the population’s quality of life

No.	Constituent entity	Salary	Employment	Population	Poverty	R integral
1	Republic of Bashkortostan	0.36	0.85	0.99	0.50	0.68
2	Republic of Mari El	0.51	0.38	0.86	0.30	0.51
3	Republic of Mordovia	0.36	1.00	0.72	0.42	0.62
4	Republic of Tatarstan	0.36	0.41	1.00	1.00	0.69
5	Udmurt Republic	0.17	0.38	0.47	0.42	0.36
6	Chuvash Republic	0.36	0.68	0.51	0.06	0.40
7	Perm Territory	0.32	0.63	0.46	0.15	0.39
8	Kirov Region	0.00	0.33	0.00	0.00	0.08
9	Nizhny Novgorod Region	1.00	0.48	0.55	0.15	0.54
10	Orenburg Region	0.15	0.18	0.37	0.12	0.20
11	Penza Region	0.46	0.00	0.53	0.03	0.25
12	Samara Region	0.48	0.30	0.75	0.21	0.44
13	Saratov Region	0.30	0.84	0.79	0.14	0.52
14	Ulyanovsk Region	0.44	0.73	0.59	0.27	0.51

Source: calculated by the authors

The assessments allow us to classify the constituent entities of the Volga Federal District according to their potential to maintain quality of life during the acute phase of sanctions. The highest level of recovery potential (in terms of the population’s quality of life parameter) is observed in the Republic of Tatarstan, the Republic of Bashkortostan, and the Republic of

Mordovia.

Our methodology focuses on the parameters of regional stability, which characterize changes in the quality of life during a crisis, and an essential component that determines the resilience of economic systems – budgetary stability. Its assessment according to the proposed algorithm is presented in Figure 8.

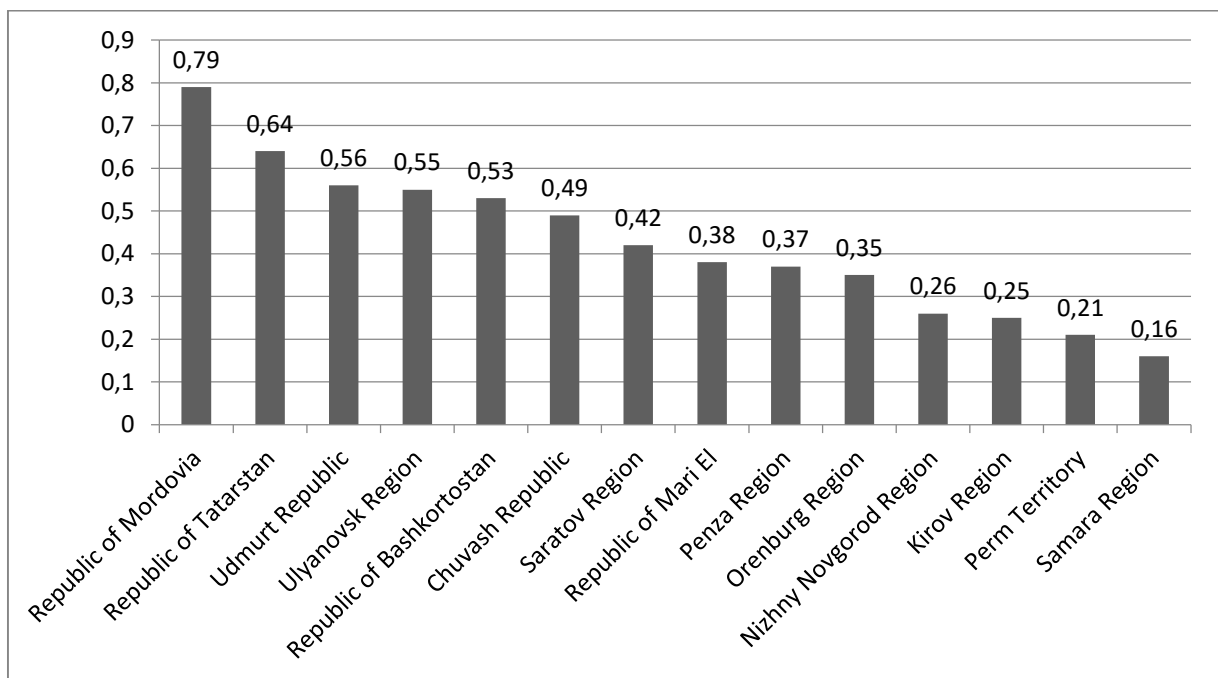


Figure 8. Integral values ($R_{integral}$) of the performance resilience index in the Volga Federal District for the budget sustainability parameter

Source: based on data from EMISS

The results showing the specific response of regional economic systems to sanctions in the context of two manifestations of resilience (the population’s quality of life and budget efficiency) form the basis for constructing an integral resilience index in the direction of performance resilience. The calculations are presented in Figure 9.

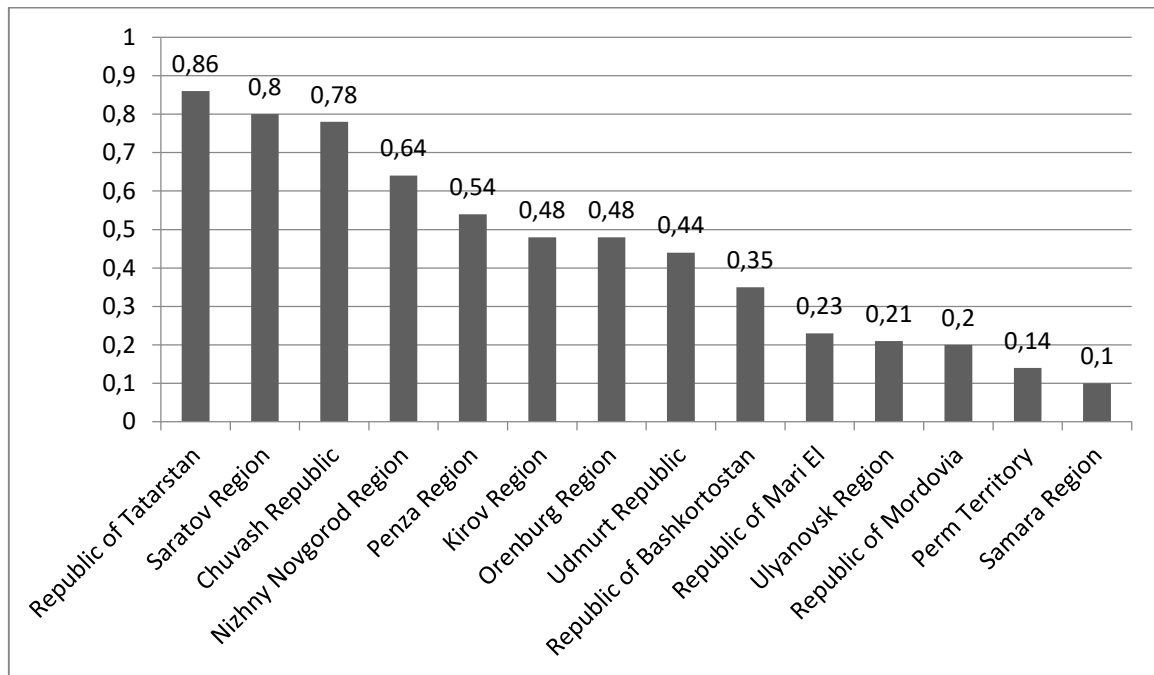


Figure 9: Integral values of the resilience index of the constituent entities of the Volga Federal District in the direction of performance resilience (R integral)

Source: based on data from Regiony Rossii. Sotsialno-ekonomicheskie pokazateli, 2023, Regiony Rossii. EMISS

The analysis shows three groups of regions characterized by their potential for economic recovery in the context of 2022 sanctions. The first group (the Republic of Tatarstan, the Chuvash Republic, the Saratov Region, and the Nizhny Novgorod Region) has a relatively high potential for crisis resilience in terms of recovery capacity. The second group (the Penza Region, the Orenburg Region, the Kirov Region, the Udmurt Republic and the Republic of Bashkortostan) demonstrates moderate resilience. The third group, including the Perm Territory, the Republic of Mari El, the Samara Region, the Ulyanovsk Region, and the Republic of Mordovia, shows average resilience to sanctions.

The standardized assessments determine the unique features of regional resilience in the Volga Federal District based on the construction of a normalized indicator matrix in the coordinate system “import dependence – export dependence (vulnerability) – performance resilience” (3D model). These assessments form the basis for constructing a 2D resilience matrix for the constituent entities of the Volga Federal District. Using the toolkit, the final results are presented in Figure 10.

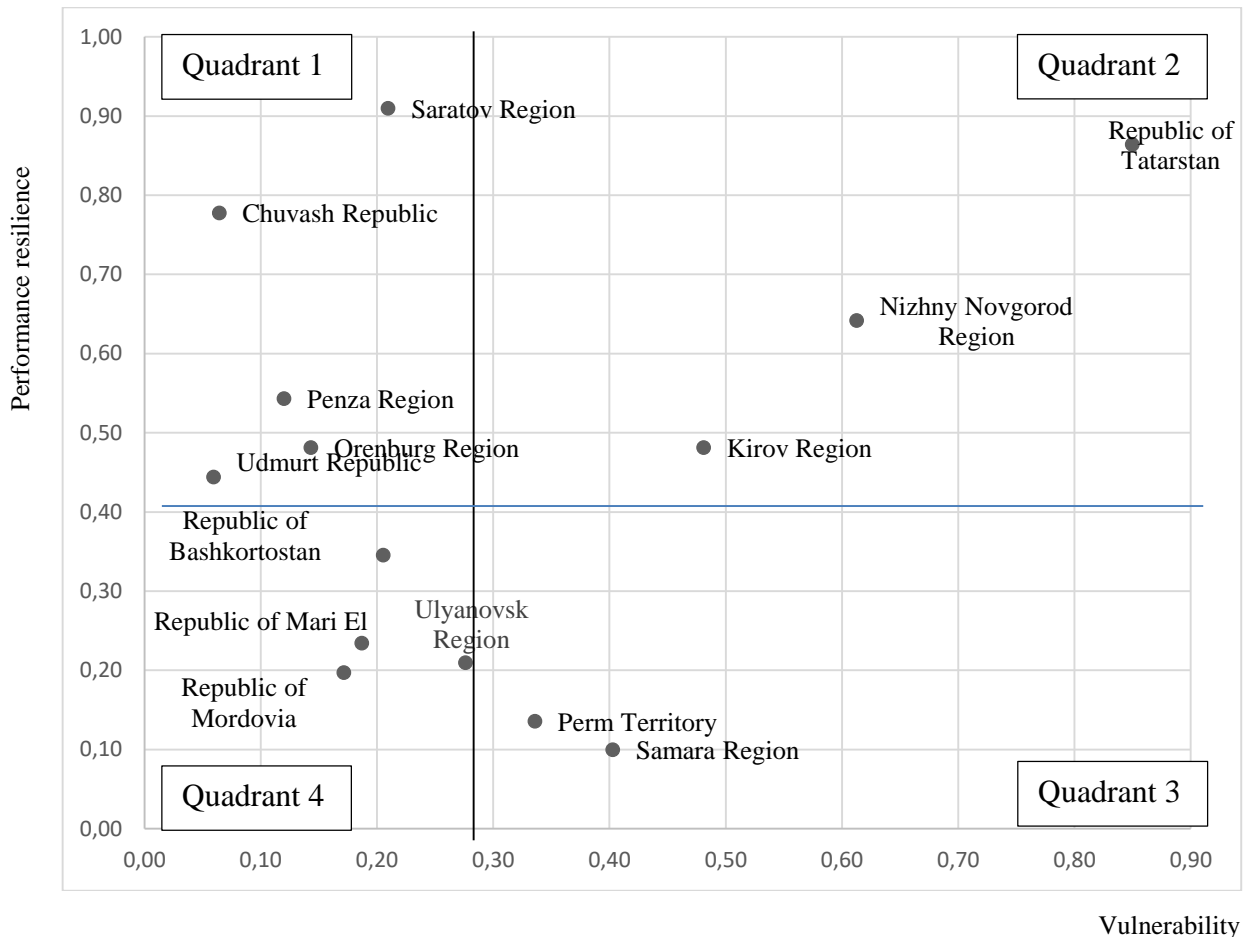


Figure 10. The distribution matrix of the regions of the Volga Federal District in terms of the ratio of resilience parameters “Vulnerability” – “Performance Resilience”
Source: developed by the authors

Our analysis distinguishes regions based on their potential to withstand macroeconomic external shocks. Our conclusions indicate that six out of 14 regions in the Volga Federal District fall within the high-risk zone of resilience. The Perm Territory and the Samara Region are classified as regional systems having significant economic ties with unfriendly countries. However, unlike the Republic of Tatarstan and the Nizhny Novgorod Region, which also have a high degree of integration into imports and exports, these regions show a moderate recovery potential in the face of 2022 systemic transformations. This discrepancy may be attributed to institutional reasons and structural economic settings. Without delving into such analysis, the

developed toolkit for assessing the resilience of regional economic systems allows for a clear identification of problematic areas in regional development in the context of macroeconomic shocks. Based on the assessments, there is a need for measures enhancing the efficiency of such socio-economic systems. This strategic analysis requires more attention and is beyond the scope of the current research objectives.

Dwelling on the assessments (Figure 10), it is necessary to highlight the regional economic systems that fall into Quadrant 1 (the Udmurt Republic, the Chuvash Republic, the Saratov Region, the Penza Region, and the Orenburg Region). These regions show a high level of resilience due to their low dependence on imports and exports with unfriendly countries. These constituent entities of the Volga Federal District form a backbone of territories with optimal settings, providing the potential to withstand possible threats and risks. This is likely due to their moderate cooperative external ties with countries that imposed sanctions on the Russian national economy.

The Republic of Bashkortostan, the Ulyanovsk Region, the Republic of Mari El, and the Republic of Mordovia are among the regions of the Volga Federal District with the most balanced level of resilience. Despite their low dependence on imports and exports, these regions have the lowest level of recovery efficiency. This could reveal suboptimal settings in terms of socio-economic development mechanisms (Safiullin et al., 2013).

5. CONCLUSIONS

Our methodological approach to the study of the resilience of regional industries is based on the synthesis of Russian and other practices with the addition of original components.

The main distinctive features include:

1. The decomposition of the category according to the proposed 3D approach, which determines the potential for assessing resilience parameters through factor analysis.
2. The aggregated indicator characterizing the vulnerability of the research object based on import and export dependence allows a better consideration of the resilience potential regarding sanctions, whose most important manifestation is the localization of access to external markets.
3. The methodological feature expressed in the construction of the resilience matrix of regional economic systems opens a new research perspective that predetermines the

possibility of identifying the prospects for regional development in conditions of turbulence or external pressure on the national economy.

Our methodological approach can be supplemented and improved from the perspective of its toolkit and the indicative base used for assessing regional resilience. The approach based on the 3D paradigm to study the resilience of regions and industries can form the core and renewed foundation for the research subject, providing a new impetus to the theory of resilience of economic systems at the macro- and meso-levels.

Our toolkit forms a basis for determining the direction and scope of government policy to enhance the effectiveness of regional development mechanisms. It provides parameters and benchmarks for localizing dependence on imports and exports to achieve acceptable or optimal levels of resilience.

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