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Economic Diagnostics of Industrial Production Risks: Regional Aspect

Diagnóstico Económico de Riesgos de la Producción Industrial: Aspecto Regional

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Anna Ter-Grigoryants
North Caucasus Federal University, Stavropol, Russian Federation
Email: ann_ter@mail.ru
ORCID: https://orcid.org/0000-0001-8957-4198

Elena Shelukhina
North Caucasus Federal University, Stavropol, Russian Federation.
Email: sheluhina1319@yandex.ru
ORCID: https://orcid.org/0000-0002-2266-5666

Galina Leonova
North Caucasus Federal University, Stavropol, Russian Federation.
Email: galina.leonova@mymail.academy
ORCID: https://orcid.org/0000-0002-3528-2023

Valeriya Statsenko
North Caucasus Federal University, Stavropol, Russian Federation.
Email: statsenko-96@mail.ru
ORCID: https://orcid.org/0009-0008-5942-6299

Abstract

The purpose of the article is to substantiate the importance of using economic and statistical methods to assess the risks associated with regional industrial development. The study focuses on analyzing absolute and relative indicators of volatility, sustainability of growth, and dynamic risks. The research methodology involves a quantitative assessment of industrial production risks, using the North Caucasus Federal District of Russia as a case study. Results indicate significant fluctuations in industrial production across different regions, highlighting areas of high risk and instability. The analysis reveals uneven development patterns and emphasizes the need for systematic risk assessment to support industrial sectors effectively. The conclusion underscores that accurate risk diagnostics are crucial for forming regional development strategies and adjusting government management in response to external volatility, ensuring sustainable economic growth and industrial progress in macroregions.

***Keywords*:** Industry, Region, Assessment, Economic and statistical methods, Dynamics, Fluctuation.

Resumen

El propósito del artículo es fundamentar la importancia de utilizar métodos económicos y estadísticos para evaluar los riesgos asociados con el desarrollo industrial regional. El estudio se centra en analizar indicadores absolutos y relativos de volatilidad, sostenibilidad del crecimiento y riesgos dinámicos. La metodología de investigación implica una evaluación cuantitativa de los riesgos de la producción industrial, utilizando como estudio de caso el Distrito Federal del Cáucaso Norte de Rusia. Los resultados indican fluctuaciones significativas en la producción industrial en diferentes regiones, destacando áreas de alto riesgo e inestabilidad. El análisis revela patrones de desarrollo desiguales y enfatiza la necesidad de una evaluación sistemática de riesgos para apoyar a los sectores industriales de manera efectiva. La conclusión subraya que los diagnósticos de riesgo precisos son cruciales para formular estrategias de desarrollo regional y ajustar la gestión gubernamental en respuesta a la volatilidad externa, asegurando un crecimiento económico sostenible y el progreso industrial en las macrorregiones.

Palabras claves: Industria, Región, Evaluación, Métodos económicos y estadísticos, Dinámica, Fluctuación.

Introduction

The ongoing socioeconomic processes in Russia have led to a reorientation of its economic sectors with due regard to the significant impact of internal and external factors. Ensuring an objective and reliable assessment of the effectiveness of industry transformation involves analyzing territorial specifics, which allows one to identify the risks in each region.

The most important object of state strategic management is the industrial complex which has a primary influence on budget replenishment and regional specialization. The formation of the industrial potential of a particular region increases its competitiveness and ability to meet market needs and ensure decent living for the population.

The uneven supply of resources to regions and their industrial differentiation stipulate the need to study alternatives to interregional interactions and search for new forms of their use to increase the efficiency and sustainability of industrial functioning in the future, which justifies ongoing research not only within individual regions but also at the level of each macroregion. An economic assessment of the results of industrial production and the risks of its development allows one to analyze their influence on the achievement of target indicators of socioeconomic development in different regions and to develop prompt corrective measures if necessary.

Theoretical and methodological research into identifying and assessing risks in industrial production contains a wide range of works. Due to the manifestation and varied impact of endogenous and exogenous, it is necessary to conduct systematic analysis and control the development of industrial production at the level of regions and macroregions.

The consolidation of Russian regions (2003-2008) is characterized by the economic and political process of administrative unification of bordering entities of the Russian Federation. The most important principles of the formation and development of macroregions are given sufficient attention since, depending on the

goal, scientists substantiate various conceptual directions for the most effective interregional interaction in the macroregional space (Skibin, 2023; Vladyko, 2022).

Public administration should reduce the differentiation of Russian regions in terms of their socioeconomic development and adequate mechanisms for the redistribution of resources to smooth out spatial inequality (Rozanova & Moroshkina, 2015). The concentration of industrial resources plays a significant role since the development of industrial production in each region depends on its territorial location. Research into the industrial space of a macroregion in the conditions of regional disequilibrium facilitates the search for mechanisms aimed at the rational interaction of its elements, the development of clusters and technology parks, and the maximum use of available resources in a specific territory.

To ensure such an effective interaction between regions, the timely and high-quality diagnostics of risks is necessary, which allows one to determine dynamic trends and identify risk zones for industry development in regions that are part of the macroregion. This risk-oriented management ensures not only the progressive development of the macroregion but also the positive dynamics of industrial sectors within regions with due regard to the mutual influence of identified risks and threats. Monitoring the implementation of tasks by regions in terms of industrial production guarantees progress in achieving the industrial sovereignty of macroregions and the country (Ter-Grigoryants et al., 2023a, 2023b).

The formation of a risk management system in industry should be based on the general theoretical and methodological foundations of risk management and the existing sectoral structure of regional industrial production. Each industry has special risks of development and normal functioning which must be diagnosed and considered when developing tactical and strategic plans (Afanasev & Suslov, 2024; Bakirova et al., 2022; Kabanova, 2023; Krivorotova et al., 2022; Neminushchii, 2023; Zubarevich, 2022). The established dynamic patterns of risk-generating factors in leading industries within a particular region can be used in the system of ensuring economic security to eliminate the causes of corresponding risks during sanctions and emerging transformations.

Methodologies and Data

Global economic science considers various methods of risk assessment within the framework of two risk theories: classical and neoclassical, which either equate risk to the mathematical expectation of losses (damages) as a result of the implementation of a given decision, or risk is identified with the most probable deviation of the value under consideration from the expected one (Aimone & Pan, 2022; Eccles & Puschaver, 1996; Fang et al., 2023; Kirzner, 1973; Zhang et al., 2024). Existing risk assessment methods have disadvantages, including the lack of tools for identifying risk events, the impossibility of using them for certain economic sectors, and the need for additional statistical data that may not be generated within the framework of the assessed risk.

The basic approach to risk assessment is a statistical method based on the characterization of socioeconomic phenomena using the law of normal distribution. Using a systematic approach, we can identify a system of industrial production risk indicators given in Table 1.

Table 1. System of risk indicators for the development of industrial production

Indicator, symbol	Calculation formula	Clarification
Range of deviation, R	$R = x_{max} - x_{min}$ *where x_{max} is the maximum value of the phenomenon; x_{min} is the minimum value of the phenomenon*	The higher the indicator, the greater the fluctuation
Oscillation amplitude, A	$A = R / \bar{x}$ *where $\bar{x}$ is the average value of the phenomenon*	The higher the indicator, the greater the volatility and the higher the risk
Dispersion, σ^2	$\sigma^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n}$ *where x_i is the actual value of the phenomenon; n is the number of values of the phenomenon*	The weighted average of the squared deviations of the actual results from the average

Indicator, symbol	Calculation formula	Clarification
Standard deviation, σ	$\sigma = \sqrt{\sigma^2}$	A decrease in variability characterizes a decrease in risk
Variation coefficient, V	$V=\pm\sigma/\overline{x}$	The higher the value, the higher the volatility of the relative trend series and the risk
Risk criterion, U	$U = \frac{a}{\sigma}$ *where a is the linear trend parameter, y=ax+ε*	If the indicator is above 1, the risk of dynamics is reduced. If the indicator is less than 1, fluctuations grow stronger than the increase in levels, and the risk of dynamics increases
Growth sustainability coefficient, W	$W = 1 - 6\sum_{i=1}^{m}\frac{d^2}{m}(m^2-1)$ *where d is the difference between the levels of the phenomenon being studied and the numbers of years in the series; m is the number of pairs of observations*	Spearman's coefficient can take values from 0 to ±1. The closer the value is to +1, the higher the sustainability of growth and the lower the risk. At zero value, growth is unstable. For negative values, the indicator decreases

Source: compiled by the authors based on a theoretical study (Afanasev & Suslov, 2024; Aimone & Pan, 2022; Bakirova et al., 2022; Doroshenko, 2023; Eccles & Puschaver, 1996; Fang et al., 2023; Kabanova, 2023; Kirzner, 1973; Krivorotova et al., 2022; Rozanova & Moroshkina, 2015; Skibin, 2023; Ter-Grigoryants et al., 2023a, 2023b; Vladyko, 2022; Zhang et al., 2024; Zubarevich, 2022)

The main tools for calculating risks are absolute and relative indicators of variability. The variability (fluctuation) of a possible outcome is the degree to which the expected value deviates from the average expected value. The higher the volatility indicators, the higher the production risk.

The low level of fluctuation does not reflect dynamics. Low fluctuations in the levels of a trend-related series may indicate a stable increasing development trend. To characterize the risk of the dynamics of industrial production, it is advisable to calculate the growth stability coefficient as a measure of frequency. To evaluate the dynamics in terms of growth stability, one can use Spearman's rank correlation coefficient. This indicator allows us to identify the direction of stability and risk of

dynamic trends. When the increase rate of the phenomenon changes, this indicator does not allow a correct assessment of the situation. Thus, it can reflect sustainable growth in the case of insignificant absolute increases in the indicator over time (Eccles & Puschaver, 1996; Kirzner, 1973).

In conditions of high uncertainty, indicators reflecting the risk of development trends should also be calculated. The basis for calculating these indicators is not the levels of the time series but indicators of their dynamics. In this case, it is necessary to add indicators of trend growth and standard deviation into the calculation algorithm.

The economic-statistical method in studying the risks of industrial production and its further development allows us to assess the share of each region and activity in the manifestation of destructive trends and processes of socioeconomic development within the macroregion.

Results and discussion

The North Caucasus Federal District is one of the federal districts of the Russian Federation, occupying about 1% of the country's area. The district is rich in various natural and balneological resources and mineral and thermal waters. This requires conditions for the effective use of its industrial potential as the basis for economic growth.

The District's industry accounts for more than 30% of the gross added value in the macroregion. Manufacturing industries provide the largest share. The food and chemical industries, mechanical engineering, and the production of building materials are characterized by positive dynamics. The District achieved an annual increase in industrial production in 2021-2023. In 2021, the industrial production index was 111.1% compared to 2020. Between 2022 and 2023, industrial production in the District increased by 6.2 and 6.1%, respectively. During each reporting year, industrial production had varying fluctuations (Figure 1).

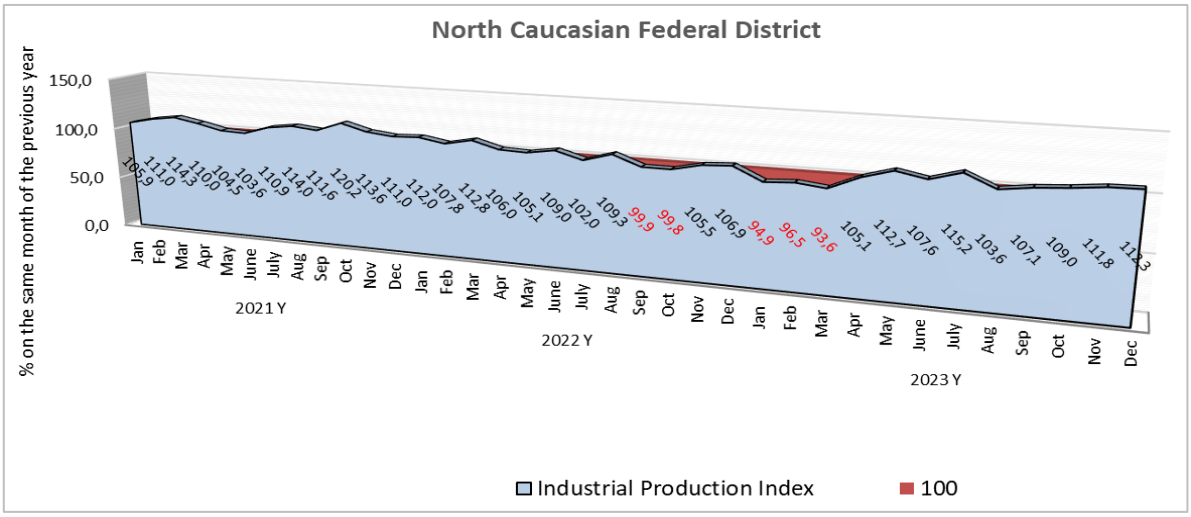


Figure 1. Dynamics of the industrial production index in the North Caucasus Federal District in 2021-2023, % of the corresponding month of the previous year

Source: compiled by the authors based on data from Federalnaya sluzhba gosudarstvennoi statistiki (n.d.), Edinaya mezhvedomstvennaya informatsionno-statisticheskaya sistema (EMISS) (n.d.)

Figure 1 demonstrates a monthly increase in industrial production in the District throughout 2021 and the first half of 2022 compared to the corresponding months of the previous year. In 2022, a decrease in industrial activity was observed in September and October. The year 2023 experienced the negative dynamics of industrial development from January to March. Over three years, five out of 36 months were characterized by a decrease in industrial development indicators. The maximum increase of 20.2% was recorded in October 2021 compared to October 2020. The maximum decrease of 6.4% occurred in March 2023.

Considering the stable growth of industrial production in the macroregion, the shipment of produced goods, work performed, and services provided in the regions of the District also show positive dynamics.

The largest share in the macroregion falls on manufacturing industries. They comprise 70% of the structure of shipped products produced in the district. According to Figure 2, products of manufacturing industries were sold for 470,954.3 million rubles in the Stavropol Territory, 54,107.5 million rubles in the Republic of Dagestan, and 38,782.6 million rubles in the Kabardino-Balkarian Republic, which is

respectively 71.2, 8.2, and 5.9% of the industrial production of the macroregion in 2023.

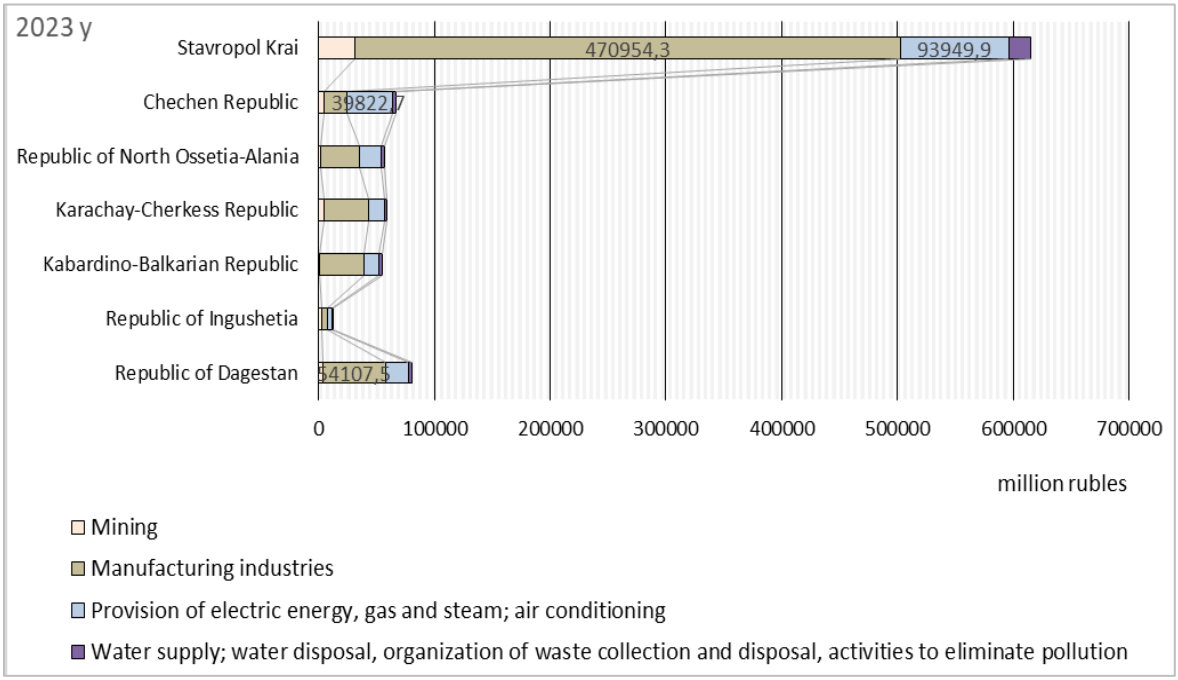


Figure 2. Shipped goods of own production and performed works and services based on own resources in the regions of the North Caucasian Federal District by industry in 2023, million rubles
Source: compiled by the authors based on data from Federalnaya sluzhba gosudarstvennoi statistiki (n.d.), Edinaya mezhvedomstvennaya informatsionno-statisticheskaya sistema (EMISS) (n.d.)

As of 2023, the District shipped products in the manufacturing industries for 661,612.7 million rubles, which is 92,290.6 million rubles more than exports in 2021 (+16.2%) and 27,374.8 million rubles more than those in 2022 (+7.3%). The leader of the macroregion in manufacturing industries is the Stavropol Territory. In 2021, the Stavropol Territory sold products of manufacturing industries for 415,075.1 million rubles (72.9% of sold goods were produced locally). The Republic of Dagestan comes in a close second, with sales of industrial products worth 50,348.7 million rubles. The Kabardino-Balkarian Republic is in third place with 44,194 million rubles. These sales amount to 8.8 and 7.8% of the total volume of industrial products in the District, respectively. In 2023, 17.2% more manufactured goods were shipped, work

was performed, and services were provided in the regions of the District in all industries compared to 2021.

Activities in the field of supplying electricity, gas and steam, and air conditioning in the District accounted to sales for 202,710.3 million rubles in 2023, which is higher than the indicator of 2021 by 35,818.9 million rubles (+29.1%). The minimum increase in shipments of the District is typical of the mineral extraction sector. In 2023, the growth rate was 107.9% compared to 2021.

Although there was an increase in industrial production in all regions in 2023 (compared to 2021), there was a decrease in sales in the mineral extraction industries in the Republic of Dagestan by 1,174.3 million rubles (-22.4%), manufacturing industries in the Kabardino-Balkarian Republic by 5411.8 million rubles (-12.2%), and water supply, sanitation, waste collection and disposal, and pollution elimination activities in the Chechen Republic by 37.1 million rubles (-1.5%).

In 2023, the Republic of North Ossetia-Alania and the Republic of Ingushetia experienced the maximum increase in industrial production in the field of mining (2.8 times) and manufacturing (2.3 times), respectively, compared to 2021.

The development of effective measures to support industrial sectors should be based on a reliable, comparable, and objective assessment of the current state of the economy. The analytical data on the monthly dynamics of industrial production during 2021-2023 allows us to assess the risk for industrial development in the regions of the District (Table 2).

Table 2. Risk indicators for industrial development in the regions of the North Caucasus Federal District in 2021-2023 calculated based on rates of additions in industrial production, expressed as % in the corresponding month of the previous year

Constituent entity	Range of deviation	Oscillation amplitude	Dispersion	Standard deviation	Variation coefficient	Risk criterion	Growth sustainability coefficient
Republic of Dagestan	84.9	6.563	525.092	22.915	1.771	0.043	0.058
Republic of Ingushetia	54.2	5.911	113.325	10.645	1.161	0.045	0.589
Kabardino-Balkarian Republic	90.8	14.362	354.298	18.823	2.977	0.011	0.214
Republic of Karachay-Cherkessia	49.8	5.491	150.307	12.260	1.352	0.003	0.157
Republic of North Ossetia-Alania	62.6	5.189	146.464	12.102	1.003	-0.006	-0.230
Chechen Republic	40.6	5.975	89.770	9.475	1.394	0.013	0.160
Stavropol Territory	32.6	5.138	56.252	7.500	1.182	-0.045	-0.597

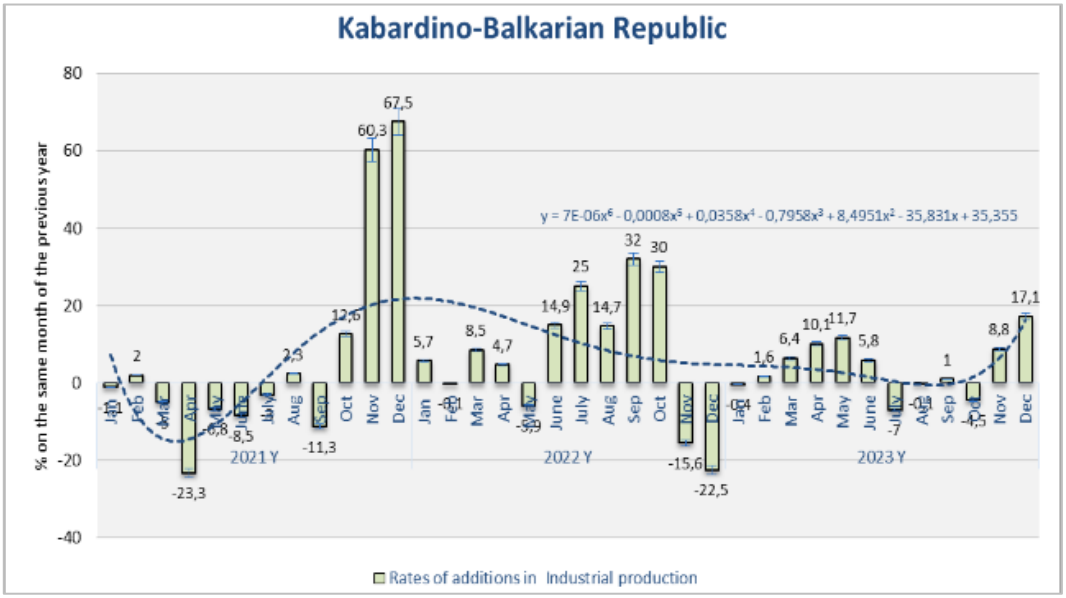
Source: calculated by the authors based on data from Federalnaya sluzhba gosudarstvennoi statistiki (n.d.), Edinaya mezhvedomstvennaya informatsionno-statisticheskaya sistema (EMISS) (n.d.)

Table 2 indicates significant unevenness in the development of industrial production in the regions of the District. The maximum level of industrial production risk during the analyzed period was typical of the Kabardino-Balkarian Republic, where fluctuations in the growth rate were more than 14%, the deviation from the average value was 19%, and the coefficient of variation was more than two times higher than the values in the other regions of the District. The lowest level of fluctuation in industrial production was noted in the Republic of North Ossetia-Alania which is characterized by the lowest coefficient of variation.

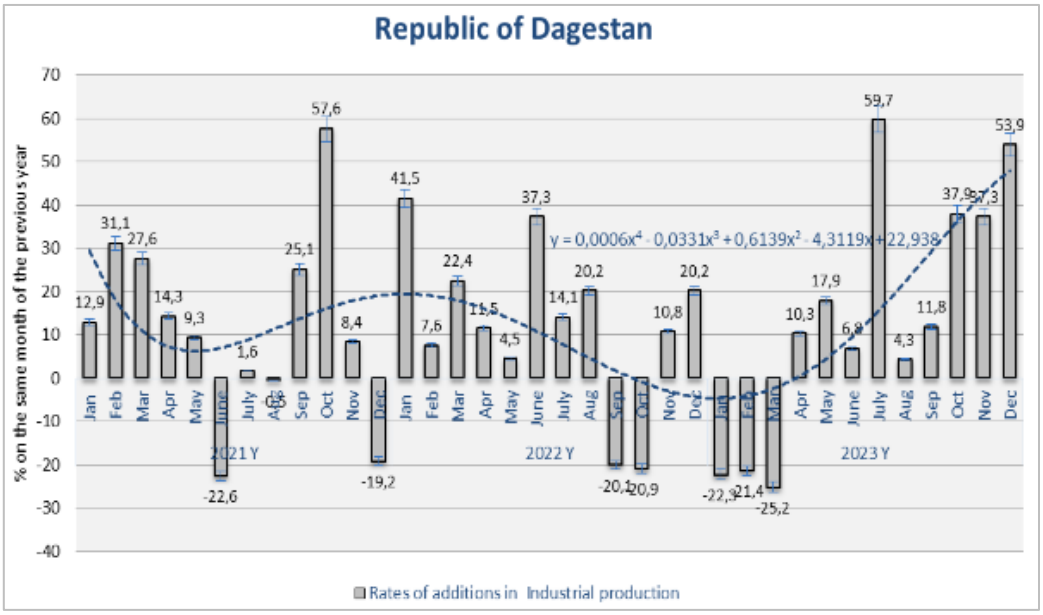
In conditions of high market volatility, it is important to use a systematic approach to the economic assessment of development trends. In the course of our research, the regions of the District were differentiated based on the level of industrial production, risk indicators, and trends in development dynamics. As a result, the grouping of regions provided for identifying risk zones with an upward or downward trend in industrial production.

Thus, the Kabardino-Balkarian Republic, the Republic of Dagestan, and the Karachay-Cherkess Republic are within the red zone of industrial development risk (Figure 3).

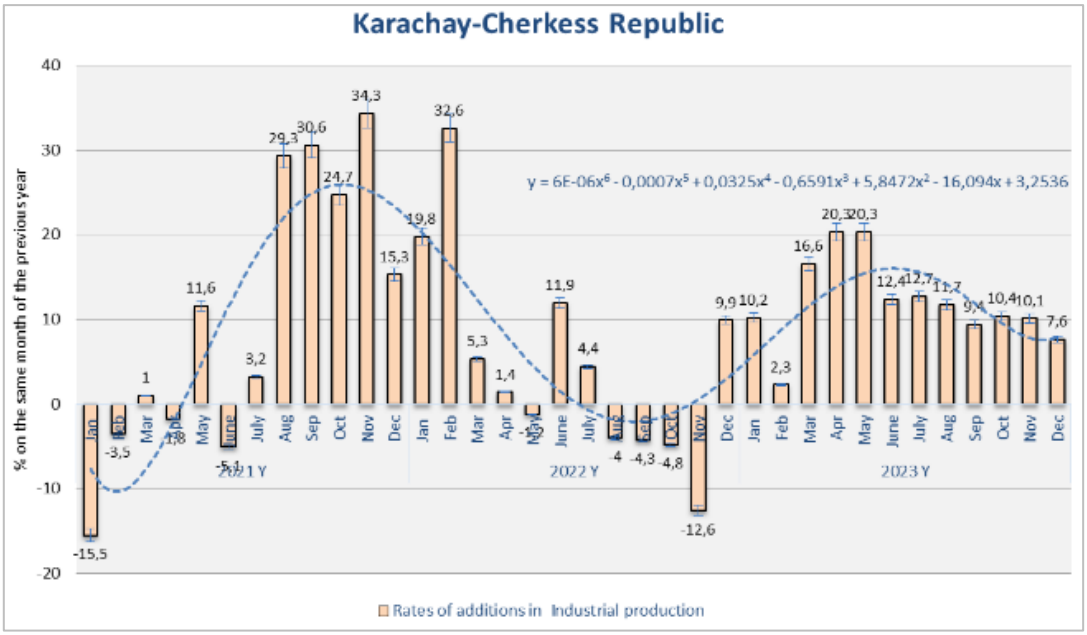
Figure 3. Dynamics of industrial production in the regions of the North Caucasian Federal District in 2021-2023, falling into the red zone and characterized by an upward trend



a) Rates of additions in industrial production in the Kabardino-Balkarian Republic, % compared to the corresponding month of the previous year (actual values, polynomial trend, and error limit of 5%)



b) Rates of additions in industrial production in the Republic of Dagestan, % to the corresponding month of the previous year (actual values, polynomial trend, and error limit of 5%)



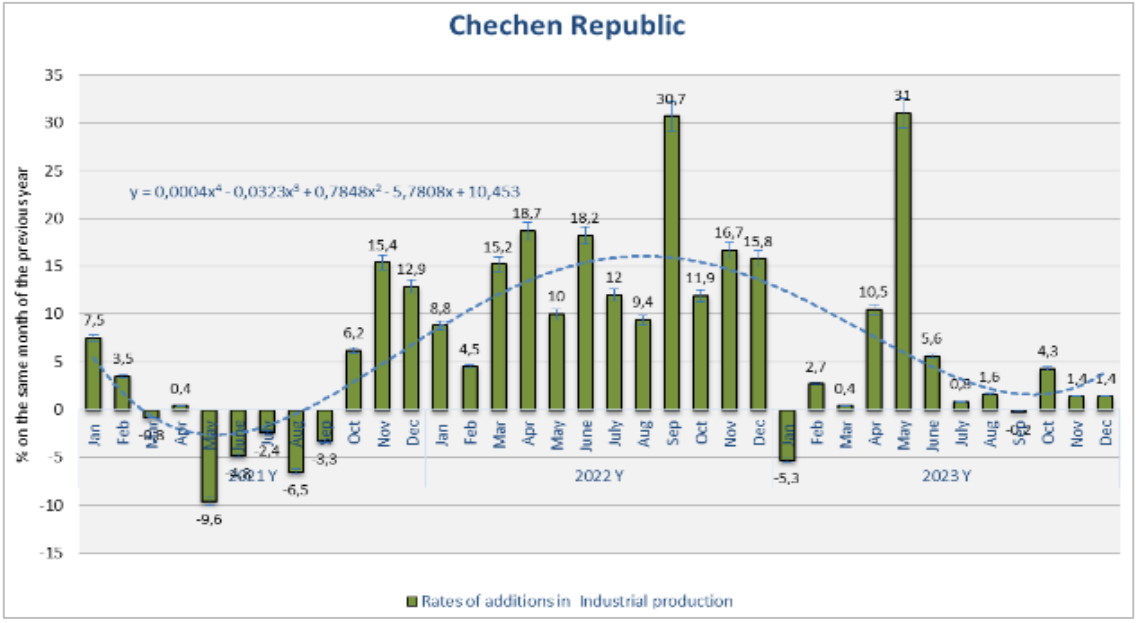
c) Rates of additions in industrial production in the Karachay-Cherkess Republic, % compared to the corresponding month of the previous year (actual values, polynomial trend, and error limit of 5%)

Source: compiled by the authors based on data from Federalnaya sluzhba gosudarstvennoi statistiki (n.d.), Edinaya mezhvedomstvennaya informatsionno-statisticheskaya sistema (EMISS) (n.d.)

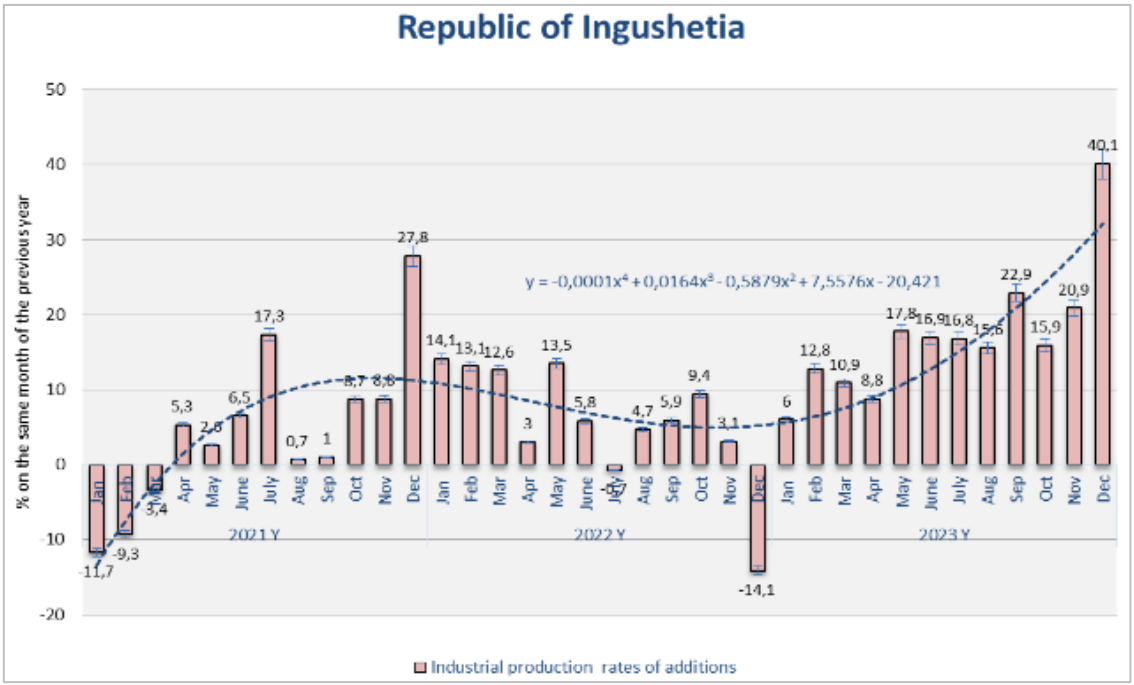
The analytical data and the performed calculations indicate a significant volatility of industrial production in the red zone regions in 2021-2023. The absolute and relative indicators of variability are maximum in the Kabardino-Balkarian Republic and the Republic of Dagestan. However, the efficiency of industrial production in the Republic of Dagestan has a positive trend. It has been growing since April 2023, and we can conclude that the production potential of Dagestan has been increasing and its rational use has been achieved.

Figure 4 demonstrates the dynamics of industrial production in the regions falling into the yellow risk zone with an upward trend.

Figure 4. Dynamics of industrial production in the regions of the North Caucasus Federal District in 2021-2023, falling into the yellow zone and characterized by an upward trend



a) Rates of additions in industrial production in the Chechen Republic, % to the corresponding month of the previous year (actual values, polynomial trend, and error limit of 5%)



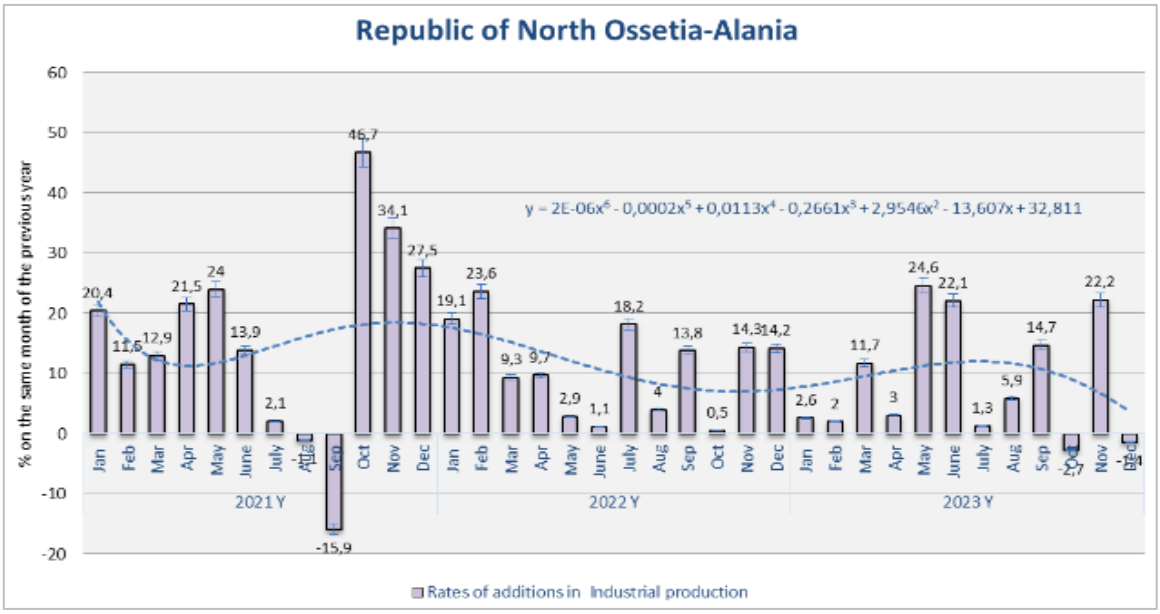
b) Rates of additions in industrial production in the Republic of Ingushetia, % compared to the corresponding month of the previous year (actual values, polynomial trend, and error limit of 5%)

Source: compiled by the authors based on data from Federalnaya sluzhba gosudarstvennoi statistiki (n.d.), Edinaya mezhvedomstvennaya informatsionno-statisticheskaya sistema (EMISS) (n.d.)

The Chechen Republic, the Karachay-Cherkess Republic, and the Republic of Ingushetia have an average level of industrial development risk and a tendency to increase production. Fluctuations are lower than the increase in levels, therefore the risk of dynamics is reduced.

The Republic of North Ossetia-Alania also falls into the yellow risk zone. Only four monthly industrial production indicators out of 36 results reflect their decline compared to the corresponding month of the previous year. Industrial production fluctuations in this region are characterized by an average level. However, the risk criterion and the growth sustainability coefficient take on negative values, which confirms a downward trend in the industrial development of this region (Figure 5).

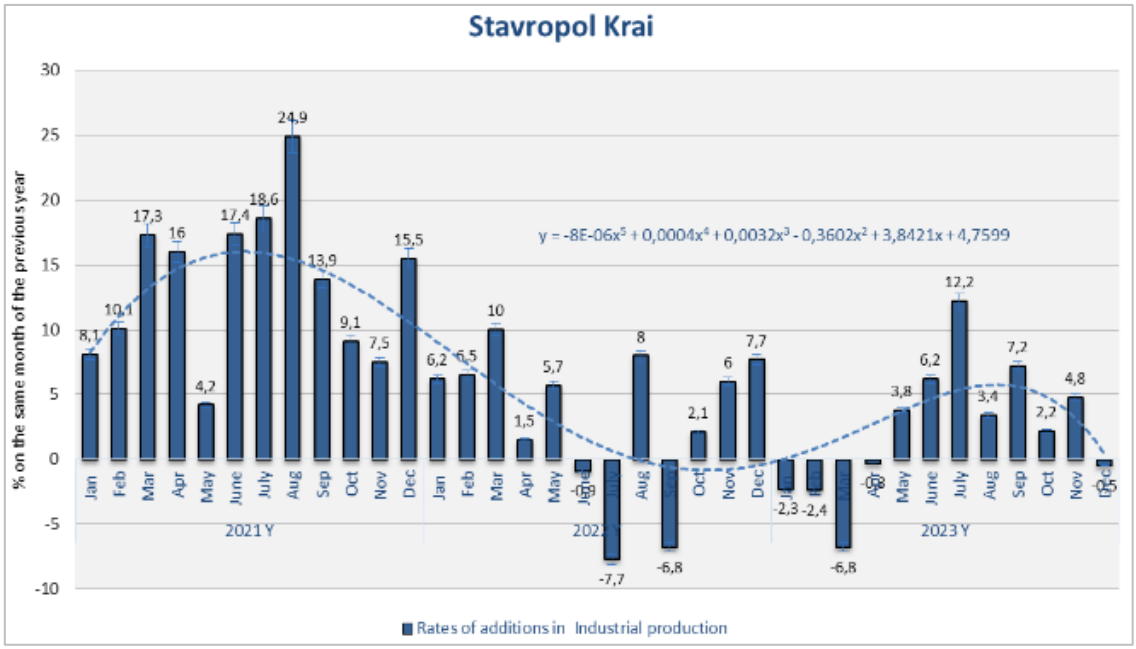
Figure 5. Dynamics of industrial production in the Republic of North Ossetia-Alania in 2021-2023, falling into the yellow zone and characterized by a downward trend (Rates of additions in industrial production, % to the corresponding month of the previous year: actual values, polynomial trend and error limit of 5%)



Source: compiled by the authors based on data from Federalnaya sluzhba gosudarstvennoi statistiki (n.d.), Edinaya mezhvedomstvennaya informatsionno-statisticheskaya sistema (EMISS) (n.d.)

Fundamentally different results were obtained for the Stavropol Territory, the driver of industrial sectors in the North Caucasus. Its absolute and relative risk indicators are minimal compared to the other regions. The industrial production trend is unstable and has not been characterized by predominant instability from the second half of 2022, as evidenced by the data in Figure 6.

Figure 6. Dynamics of industrial production in the Stavropol Territory in 2021-2023, falling into the green zone and characterized by a downward trend (Rates of additions in industrial production, % to the corresponding month of the previous year: actual values, polynomial trend, and error limit of 5%)



Source: compiled by the authors based on data from Federalnaya sluzhba gosudarstvennoi statistiki (n.d.), Edinaya mezhvedomstvennaya informatsionno-statisticheskaya sistema (EMISS) (n.d.)

The calculations show that the average monthly growth rate of industrial production in the Stavropol Territory was 106.3% in 2021-2023 if compared to the corresponding month of the previous year. The minimum industrial production index was 0.92, and the maximum value amounted to 1.25. Fluctuations in industrial production are larger than the increase in its levels, and the risk of dynamics is also growing.

Industry in the District is characterized by significant unevenness and risk of development with a prevailing tendency of instability. In recent years, trends in the dynamics of industrial production have shown the mobilization of industrial potential in the macroregion and effective adaptation to emerging endogenous and exogenous factors.

Conclusion

Trends in the economic development of constituent entities of the Russian Federation are largely predetermined by the level and dynamics of industrial production, which depend on emerging industry restrictions and corresponding structural shifts in the country's economy. Under increased volatility of the external environment, the formation of regional development strategies and the adjustment of government management in industry should be based on a relevant, objective, and reliable assessment of the processes characterizing the conditions and results of realizing industrial potential.

Using a systematic approach to the economic analysis of trends in the development of industrial sectors helps differentiate the regions of the North Caucasus Federal District based on the current level of their industrial production, absolute and relative indicators of its variability, and risk criteria for the level and sustainability of growth. A reasonable toolkit for assessing the risk of industrial development allows one to identify both upward and downward trends in industrial production, which is of primary importance for the development of management actions that are adequate to the current market situation.

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