

DOI: 10.15838/esc.2026.3.105.3

UDC 332.02

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Formalizing the Economic Immunity of Industrial Regions: A Pilot Testing Experience

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Abstract. Industrial regions, which constitute the core of Russia's technological development and underpin its leadership positions on the global stage, deserve particular attention as they find themselves under the influence of geo-economic factors. The aim of this study is to develop a methodological approach that makes it possible to formalize the economic immunity of industrial regions in the face of adverse external impacts. The theoretical and methodological basis includes a set of approaches to assessing the shock resilience of territories and to identifying the dependence of their economic development on prior trajectories. The principal methodological toolkit proposed in the study is a matrix that integrates, on the one hand, assessments of the economic predisposition of industrial regions toward resistance and recovery – which determines the protective mechanisms against external shocks – and, on the other, narrative express analysis, which reveals the preconditions for the genesis of a new economic development trend that underpins a territory's adaptation to changing economic conditions. The study period spans 2009–2025; testing was carried out on 36 industrial regions of the Russian Federation. According to the resulting matrix, the indicators that proved most sensitive during the period of exposure to external shocks in regions where manufacturing accounts for $\geq 25\%$ of GRP are the average annual number of people employed in manufacturing and spending on technological innovation. In industrial regions

For citation: Myslyakova Yu.G. (2026). Formalizing the economic immunity of industrial regions: A pilot testing experience. *Economic and Social Changes: Facts, Trends, Forecast*, 19(3), 48–64. DOI: 10.15838/esc.2026.3.105.3

with a diversified economy, it is fixed capital investment that suffers substantially. At the same time, industrial regions with a diversified economy display greater economic resilience than regions specializing in manufacturing. The Novosibirsk Region possesses the strongest economic immunity, followed by the Moscow Region and the Republic of Tatarstan. Half of the industrial regions are characterized by vulnerable economic immunity, and 36% have a disruptive protective mechanism alongside a vulnerable activating mechanism. It is stressed that factoring in the predisposition of regions, as one of the elements of economic immunity, will make it possible to ensure the evolutionary nature of the national economy's development. The findings may prove useful to public authorities in improving regional strategies for socio-economic development.

Key words: economic immunity, heredity, region's resistance, region's recovery, region's predisposition, sustainable economic development, manufacturing specialization, diversified economy.

Acknowledgment

The article was prepared as part of the state assignment of the Russian Ministry of Science and Higher Education for the Institute of Economics of the Ural Branch of the Russian Academy of Sciences for 2026, under research theme No. 0327-2024-0015, "Methodology for Shaping a New Model of Sustainable and Economically Secure Spatial Development of Industrial Regions".

Introduction

The heightened scholarly attention to the sustainable development of the national economy stems largely from the fact that territories have become more vulnerable to shock disturbances amid geopolitical challenges and varying degrees of integration among countries on the global stage. Industrial regions, which form the core of the Russian Federation's innovative and technological development and are responsible for its leadership positions in international markets, deserve particular attention. The effectiveness of preventive measures that allow such territories to evolve gradually is substantially constrained under conditions of instability. This makes it essential to apply knowledge about the established features of their functioning and development trajectories in order to identify, in a timely manner, when defense mechanisms need to be activated and to design institutional pathways for strengthening them.

At present, the concept of "immunity", which has entered interdisciplinary discourse from medicine – where immunology understands it as the body's defense mechanism against external

and internal pathogens (Kiseleva, 2011) – is beginning to be actively employed in the economic sphere, highlighting one or another aspect of this phenomenon's manifestation. Thus, the institutional-legal aspect of territorial immunity is presented in the scholarly literature through special legal conditions governing economic activity, by virtue of which individual entities are afforded the opportunity to perform functions, duties, and exercise rights in the interests of the state, society, and individual citizens (Yakovenko, 2010). Here, the value of immunity lies in safeguarding the socially and economically significant, useful ties and functions performed by economic entities, which makes it possible not only to preserve but also to develop functioning economic institutions.

The social aspect of regional immunity manifests itself as society's ability to withstand external social risks and threats stemming from the penetration into society of values, norms, and behavioral patterns belonging to other cultures – patterns that destroy its integrity, integration, and adaptive potential. The economic aspect,

to a greater degree, reflects the resilience-related characteristics of both economic entities (production chains) and the territory as a whole under the negative impact of external environmental factors, and it manifests itself in ensuring the country's technological sovereignty, integration into the global scientific space, investment attractiveness, and the production of high-tech products in demand on both domestic and international markets. Understood in this context, the value functions of a territory's immunity are the protection, resistance, and adaptation of economic entities to exogenous negative impacts caused by systemic and sudden financial threats (Zhakupov, 2013). According to N. Luhmann, immunity serves as a source for preserving the stable condition of a territorial socio-economic system and contains the measures necessary to support the resolution of current problems, so that the region can function with its inherent efficiency while maintaining the growth rate of its GRP (Luhmann, 2007). That is, this phenomenon reflects the degree to which the region itself is immune to, or absorbs, adverse factors impacting it.

At the same time, the interpretations presented above are better suited to defining the mechanisms for ensuring shock resilience, a topic that has been extensively studied in both Russian and international literature to date and is usually explored within the framework of an adaptive or a systemic approach, but not an evolutionary one. Since the application of the concept of immunity to the study of regional economic development is at issue, the methodology for its formation must take into account the historically shaped territorial determinants of socio-economic relations that condition it. In support of this scholarly position, one may cite the words of M.Yu. Kazakov, who understands a territory's economic immunity as a unique combination of "innate" and "acquired" factors, together with conditions of a natural character, that generate the necessary output "products" for the system's

vital activity and prevent it from disappearing or becoming deformed (Kazakov, 2018).

In order to link innate and acquired factors, the latter must be shaped with due regard for the inherited predisposition of industrial regions. This is necessitated, first, by the fact that a region is an open and economically non-isolated system, functioning under conditions of global transformation (Galbraith, 1999; Medvedev, 2016): the gradual erosion of boundaries between markets; the growing diversity of economic ties; the high-speed cross-country mobility of technologies; the intellectualization of the world economy; the creation of knowledge-intensive products using global scientific and technological platforms; the investment attractiveness of international cooperation; and the like (Vazhenin, Vazhenina, 2012). The emergence or escalation of each of these meta-processes constitutes a shock for an industrial region, one that demands the design and implementation of protective measures capable of ensuring compromise and the search for a reasonable balance of territorial interests within the economic space of the global community.

Second, a region represents a large number of interconnected elements, each possessing its own endogenous dynamics and a co-evolutionary pattern of development with the others (Mokhov, 2018). When subjected to an external negative impact, a regional socio-economic system needs to return to the stable state in which it existed before the shock. This return to equilibrium must be accomplished by the system independently, without disruptions to its functioning, which demands the autonomous and efficient use of sustainable development resources and the preservation of their quality at minimal expenditure. When the scale of the economic shock exceeds the resilience threshold of the regional system, the system does not return to its original state but instead strives to transition to a new equilibrium position. Such a movement is accompanied by qualitative changes in the

internal structure, shifts in functional dynamics, and a redistribution of resources, which signifies a transition from simple recovery to adaptive transformation – a transition that provides the next evolutionary step in development.

Third, the actors within a regional economic system maintain constant yet individually varying degrees of interaction with the external environment (Nekipelov, 2003; Yakovets, 2001). At the same time, the region possesses the capacity to reproduce its core components and to ensure their ordered coherence. It follows, then, that different socio-economic trajectories of changing conditions and development are possible for regions under the negative impact of the external environment. For instance, an economy may return to its original trajectory without long-term deviations. However, if the reorientation process entails sufficiently radical changes, the economy may not return to its previous state but may instead ascend to a higher technological level of growth through positive hysteresis effects, or embark on a new trajectory with a higher long-term trend. These scenarios demonstrate that regions' reactions to external shocks are path-dependent and are conditioned by structural characteristics, institutional adaptability, and the scale of the transformations involved (Auzan, 2015). This once again confirms the idea that a region's response to negative impacts can manifest itself in a variety of ways, yet at its foundation always lies its past development path (economic heredity), which, among other things, determines the territory's inherited predisposition to a particular type of behavior in a situation that is stressful for it (Auzan, 2025).

The triad of methodological considerations outlined above necessitates that every region develop its own immunity: a hereditary economic mechanism for maintaining positive dynamics in the key indicators of a territory's economic practice, one that enables adaptation to the new realities of economic life by transforming the structural

elements of the regional system while preserving the integrity and functionality of the historically formed linkages among them.

As G. Vollmer observed, in the real world “a continuous historical and genetic connection exists between individual states across all spheres of reality, where the existence of a first event conditions the existence of a second, the first event being the cause that brings about the second event – the effect” (Vollmer, 1998). M.Ya. Kovalzon noted that “...the decisive role in the history of society's development belongs to human activity. At the same time, if economic theory and practice ignore the objective determinants of this activity, then the heroic efforts of a billion people will yield not ten thousand years of happiness for ten years of labor, but economic and social chaos” (Kovalzon, 1985). In his works, J. Schumpeter touched upon the idea that any economic event arises not simply from a preceding economic condition, but from its preceding general condition; that is, one must take into account all the factors “that characterize the very picture of the state, or determine the course of the process” (Schumpeter, 2022). N.D. Kondratiev still more precisely underscored the importance of accounting for the heredity of territories when ensuring their economic development, speaking of the factors that shape the economic cycle. As these factors, the scholar identified objective economic, material-technical, and innovative prerequisites that, long before an economic impetus arises, accumulate, are synthesized, and are stored within the existing regional practice, awaiting the moment of their large-scale expansion when the conditions of the territory's external environment change or global challenges emerge.

It follows that a region's economic immunity endows it with the characteristics of sustainable development, not least by taking into account the determinants of heredity – specifically, predispositions – whose consideration makes it possible to accelerate or moderate the exit from

crisis processes under the influence of destabilizing factors. This understanding of economic immunity makes it possible to formalize it in terms of such regional characteristics as:

- predisposition toward economic resistance to negative external impacts – the capacity for stabilization through the prevention of functional disruptions and economic decline when confronted with external negative factors or shock disturbances;
- predisposition toward economic recovery – the capacity to return rapidly and on a large scale (engaging all actors of the regional socio-economic system) to the original state within the context of adaptation to the conditions of a new reality;
- predisposition toward the genesis of new economic development trends – the capacity of a region's hereditary determinants (a concept elaborated in the author's earlier works (Myslyakova, 2022; Myslyakova, 2025)) to generate fundamentally new directions of economic development, adapted to the new realities of economic practice, and thereby to contribute to improving the processes of resistance and recovery under conditions of shock disturbances. The source of this genesis, according to S.Yu. Glaziev, lies in the population's readiness for the economic transformation of society, which determines the direction and course of the reforms (Glaziev, 2018). This readiness can be identified by analyzing the narratives that reflect the value-based and behavioral attitudes of regional societies (Vólchik, 2017). Narratives present in the collective memory nudge individuals toward a particular model of economic behavior, because they shape an understanding of the cause-and-effect relationships underlying economic well-being, subordinating personal convictions to the components of a society's current socio-cultural code (Collier, 2016; Tomasello, 1999). It is therefore important to identify the dominant narratives that represent institutional practices and are capable of orienting society toward the diffusion of major innovations, toward participation in them, or, conversely, toward

resistance to the transformations ahead (Algan, Cahuc, 2010; Malone et al., 2017).

These characteristics (predispositions) of a region are activated by the core of its genotype (Myslyakova, Neklyudova, 2021) and govern the principles according to which economic linkages are transformed. The first two predispositions largely reflect the protective function of economic immunity, while the third reflects its activating function – the effectiveness of adaptive economic transformations to the conditions of a new reality. This protective-activating functionality makes it possible to conclude that a territory's immunity serves as an instrument for the evolutionary development of its economy and is responsible for the processes of inheriting and strengthening its defenses, endowing the region with the necessary set of active indicators exhibiting positive dynamics.

The author's understanding of economic immunity provides the impetus for formulating the study's aim: to develop a methodological approach that makes it possible to formalize the economic immunity of industrial regions. Achieving this aim requires solving the following tasks: to substantiate the economic development factors responsible for the immunity of industrial regions; to propose a methodological approach to formalizing the economic immunity of industrial regions; and to test the toolkit and identify those regions possessing the greatest degree of economic immunity.

The novelty of the proposed approach lies in refining the understanding of the economic immunity of an industrial region and in developing an evaluation toolkit that allows its hereditary predisposition to be taken into account, with a focus on the formation of a new trend in the development of the national economy. This will make it possible to regard the phenomenon under study not merely as a static one – reflecting a region's behavioral performance under conditions of stress – but also as a dynamic one, generating the prerequisites for further economic development.

Materials and methods

To substantiate the selection of factors that shape the immunity of industrial regions, we present the following arguments.

1. Human capital has a positive impact on sustainable economic development (Martin, Sunley, 2015; Crescenzi et al., 2016; Cappelli et al., 2021). According to the work of T. Abrha and B. Weldeyohans, education, practical competencies, and health constitute the basic factors promoting economic resilience (Abrha, Weldeyohans, 2025). The higher their levels, the more adaptive and productive the economy becomes, while investments in education enhance a state's capacity to respond effectively to shock disturbances. In the view of E. Kokkinopoulou, A. Bouteraa, and F. Bouaziz, education not only develops individual capabilities but also generates positive externalities that strengthen the quality of regional institutions, since economic inequality is reduced through knowledge-driven productivity growth (Kokkinopoulou et al., 2025; Bouteraa, Bouaziz, 2023). It follows that regions with a larger pool of skilled labor suffer less from economic shocks thanks to the accumulated knowledge that engenders the socio-economic adaptability of the workforce (Martin, Gardiner, 2019). Moreover, regions that invest in professional training and workforce development achieve greater employment stability, since skilled workers are less susceptible to layoffs and turnover (Molina, Ortega, 2003; Kitsos, Bishop, 2018). For industrial regions, no less important a composite indicator is the employment share in manufacturing industries, which constitutes the core of sustainable development for both the regional and the national economy as a whole.

2. Innovation (Balabanova, 2025) and high-tech production enhance regional adaptability through the introduction of new technologies and business models that facilitate industrial renewal and stimulate cross-sectoral dynamism (Audretsch et al., 2015; Angulo et al., 2018). In the sphere of production chains, for example, robots have

become a revolutionary tool (Segun-Ajao, 2025). F. Santoso found that countries with advanced digital infrastructure, a skilled workforce, and innovative potential cope better with shocks and recover from them (Santoso et al., 2024). J. Kim argues that more highly developed information and communication technology infrastructure – measured by internet access, the number of mobile subscribers, and digital readiness – made it possible to offset GDP losses despite high morbidity rates during the COVID-19 pandemic (Kim et al., 2022). Y. Tian and L. Guo note that digital technologies boost productivity, serving as a modern instrument and platform for modernization processes in industry, which not only enhance regions' capacity for short-term recovery but also strengthen the sectoral structure of GRP over the long term (Tian, Guo, 2023).

3. Sectoral structure of the economy (Tan et al., 2020; Martin, 2012). Specialization in fast-growing industries can boost productivity, yet at the same time it renders a region more vulnerable when those industries experience a downturn (Cainelli et al., 2019; Geelhoedt et al., 2021). Some studies show that economies dependent on manufacturing are more sensitive to recessions, whereas regions in which knowledge-intensive services predominate recover more quickly (Giannakis, Bruggeman, 2020). Moreover, diversified economies tend to be more resilient, since risks are distributed across sectors and the economy adapts more flexibly to external shocks (Sutton, Arku, 2022). Indeed, a more diversified and developed industrial structure can reduce a region's dependence on a single production chain and create a "buffer zone" for risk distribution. Within this conceptual framework, related variety promotes long-term innovation by stimulating synergy among technologically linked industries, while unrelated variety enhances short-term resilience by shielding regions from sector-specific shocks (Hu et al., 2022). A diversified economy also implies stronger financial capacities at the regional level, since local authorities have more resources to build and maintain modern transport,

logistics, and information-communication infrastructure, and to create effective digital platforms for the provision of industrial services and emergency management systems. This directly reduces the systemic baseline risks faced by economic entities.

The primary regional indicators analyzed, which, on the one hand, react rapidly to shock disturbances and, on the other, characterize territories' predisposition toward economic resistance and recovery, are as follows:

- average annual number of persons employed in manufacturing (L);
- volume of goods shipped by manufacturing industries (P);
- number of employed persons with higher education (Kn);
- investment in fixed assets (Inv);
- volume of innovative goods, works, and services (Inn);
- expenditure on technological innovation (Techn).

The methodological approach to formalizing the economic immunity of an industrial region consists of three steps: 1) assessing the protective mechanism in terms of indicators of economic predisposition; 2) assessing the activating mechanism in terms of the predisposition toward the genesis of a new economic development trend; 3) a matrix-based assessment that integrates the results obtained.

Step 1. The methodological tools that can be used in this step range from descriptive and interpretive case studies to complex static econometric models (Evans, Karecha, 2013); simple Martin indices (Martin, 2012) or Augustine indices (Augustine et al., 2013); statistical time-series models, as in the work of Fingleton (Fingleton et al., 2012); and, finally, structural causal models, as presented in the works of Doran and Fingleton (Doran, Fingleton, 2013) or Fingleton and Palombi (Fingleton, Palombi, 2013), among others. However, all these complex measurement approaches presuppose a methodological framework

for estimating the trajectory along which the region would have developed in the absence of external negative impacts (Han, Goetz, 2019; Sensier et al., 2016). It is assumed that the region's pre-shock average growth rates persist, making it possible to calculate resistance and recovery as deviations from this counterfactual path. Yet such an approach requires a sufficient volume of time-series data, and the underlying economic dynamics must remain unchanged over an extended period (Martin, Gardiner, 2019).

Within the framework of our study, we propose applying a comparative approach that makes it possible to assess the indicative behavior of industrial regions in relation to national economic trends (Martin, 2012; Faggian et al., 2018; Murua, Ferrero, 2019). This approach rests on the assumption that every region's economy should strive to achieve the same growth rates as the national economy and to have the capacity to increase them. Deviations from this benchmark in the regions during and after shocks point to the relative level of their resistance to the crisis and of their recovery once the crisis has receded.

A territory's resistance to negative trends will be measured in the context of its sensitivity to external shocks, while recovery will be understood as the degree to which it returns to its previous path (additionally identifying whether a reorientation has occurred will most likely not be possible). Thus, to assess the protective mechanism, we will use the selected indicators and compare their rates of change against the expected national ones.

First, both indicators must be normalized relative to national trends (Formula 1).

$$(\Delta E_i^{t+k})^{expected} = \Delta g_N^{t+k} * E_i^t, \quad (1)$$

where g_N^{t+k} – denotes the rate of contraction or expansion of the national indicator; E is the indicator in the i -th region; t is the base year, which serves as the turning point for contraction or expansion; and k is the duration of the contraction or expansion periods.

Next, the resistance and recovery indicators for industrial regions should be calculated using Formulas 2 and 3.

$$Resistance_i = \frac{(\Delta E_i^{Contraction}) - (\Delta E_i^{Contraction})^{expected}}{|(\Delta E_i^{Contraction})^{expected}|}, \quad (2)$$

$$Recovery_i = \frac{(\Delta E_i^{Expansion}) - (\Delta E_i^{Expansion})^{expected}}{|(\Delta E_i^{Expansion})^{expected}|}, \quad (3)$$

If a region under analysis exhibits the same level of resistance and recovery as the corresponding national indicator, it is assigned a value of zero.

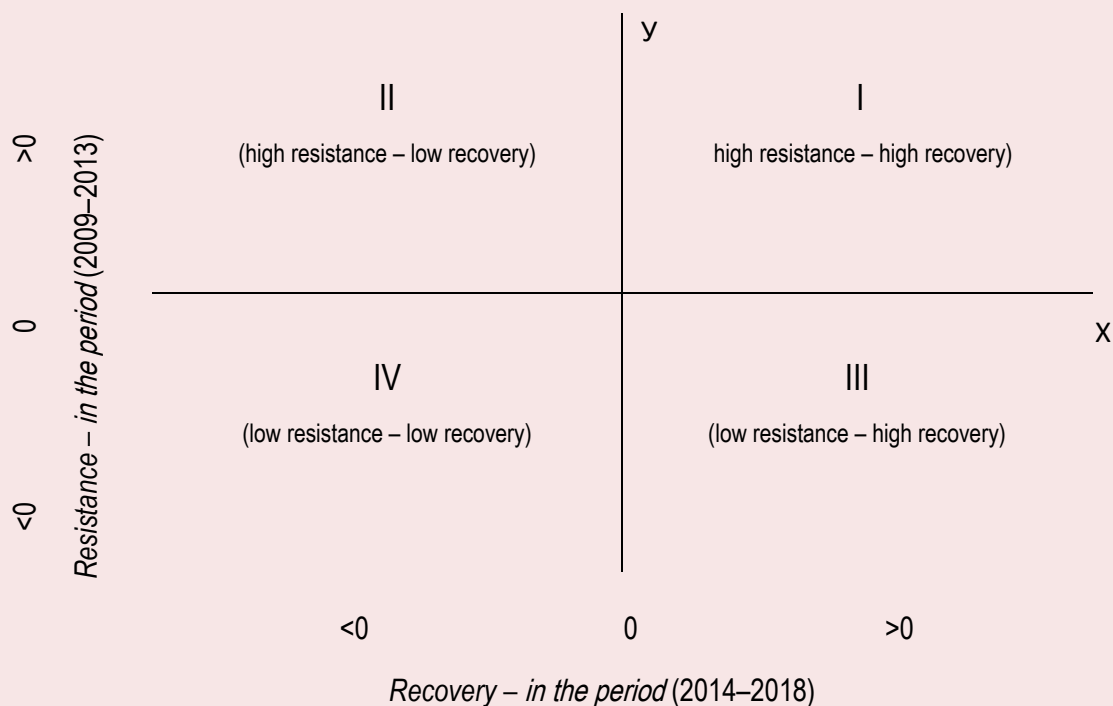
Positive values reflect stronger resilience, while negative values indicate weaker performance compared to national trends. Each resulting variable is binary: that is, it takes the value of 1 for regions

with high resistance (where the change in the indicator under analysis exceeds the dynamics of the equivalent nationwide indicator) and high recovery, and a value of -1 for the reverse cases.

Within this matrix, regions are analyzed across all indicators involved in shaping immunity (P, L, Kn, Inv, Inn, Techn); the results are then combined into an overall assessment that makes it possible to identify and formalize the characteristics of the protective mechanisms for each industrial region (Fig. 1).

In order to compare regions according to their protective mechanism in subsequent analysis, we propose using a scoring scale that converts qualitative indicators into quantitative ones according to the following principle: if a factor falls in

Figure 1. Assessment of the factor ensuring the economic immunity of an industrial region in the “resistance–recovery” system



Quadrant I comprises regions with strong resistance and strong recovery - the most protected group. Quadrant II represents regions with weak resistance but strong recovery, whereas Quadrant III includes regions with strong resistance but weak recovery. Quadrant IV contains regions with weak resilience and weak recovery - the least resilient group.

Source: own compilation.

Quadrant I, it is assigned a value of 5 points; if it falls in Quadrant II or III, 2.5 points; and if it falls in Quadrant IV, 0 points. The score is obtained by summing the corresponding assessments (Protection). This makes it possible not only to analyze the structural components of the protective mechanisms of economic immunity, but also to classify industrial regions according to the criterion of strong (21–30 points), vulnerable (11–20 points), and undermining (0–10 points) protective mechanisms.

Step 2. The assessment of the activating mechanism, as noted earlier, is proposed to be conducted through a narrative express analysis, which makes it possible to identify the prerequisites for the formation of a new trend in economic transformation. The methodology for selecting the narratives that activate the protective mechanisms of industrial regions' development is then defined by the questions they must be capable of answering: Who or what processes determine the content of the economic development of industrial regions? How can the sustainability of industrial regions' economic development be achieved under conditions of shock disturbances?

The narrative answer to these questions, which must be evaluated, can be presented as the following solution: in order to trigger the mechanisms that activate the protection of economic development under conditions of external shocks, a new code of societal transformation is needed – one that involves turning data into a key economic asset and

transitioning to algorithm-based governance in all spheres of life; creating a platform ecosystem that ensures a new quality of life for the population; attracting and retaining professionals as the capital of industrial transformation; introducing robotic automation of production, including the application of Industry 4.0 technologies; and designing an institutional environment that enhances the demand for and the effectiveness of digital solutions being implemented in economic practice.

Since a narrative normally contains a setting, a moral, a plot, and a character, and represents the resolution of some event, the sought-after narrative can be expressed through quantitative indicators as follows (*Tab. 1*).

We then obtain:

$$Narrative_D = \sqrt[4]{\bar{S} * \bar{M} * \bar{St} * \bar{P}}, \quad (4)$$

where each of the four indicators characterizing the narrative is calculated using Formula 5.

$$\bar{S}/\bar{M}/\bar{St}/\bar{P} = 1/n * \sum_{i=1}^n N_{S/M/St/P}, \quad (5)$$

where:

$S/M/St/P$ – elements of the narrative (setting/moral/plot/character);

$N_{S/M/St/P}$ – the structural component of the setting/moral/plot/character that characterizes the formation of the region's digitalization narrative;

n – the number of structural components reflecting, respectively, the setting/moral/plot/character of the sought-after regional narrative.

Table 1. Baseline narrative reflecting the genesis of a new economic development trend

Narrative element	Narrative content	Key words in Yandex search queries
Setting (S)	Data as a new asset	big data, data analyst
	Digital sovereignty	Russian software, MAX, Russian cloud services
Moral (M)	Platforms shape a human-centric ecosystem in the region	Online bank, buy online (marketplaces), communication platform, online learning (online courses / online school), personal data, gosuslugi login to personal account
Plot (St)	Robotization and Industry 4.0	Robotics, chatbot for business, digital twins of production, industrial internet of things, PLM system
Character (P)	Talents as part of capital	IT specialist, freelancing, remote work, second higher education
Resolution (Narrative_D)	Strategies for forming the digital code of economic development in industrial regions	
Source: own compilation.		

In order to assess the extent to which regions are involved in the genesis of a new economic development trend, $N_{S/M/St/P}$ to rank them, and to classify them, it is recommended that this indicator *Narrative_D* (calculated, within the framework of the study, on the basis of the volume of queries containing the keywords listed in Table 1 and made on the Yandex Wordstat platform) be compared to the employed population figure for the same period, which serves as the labor resource for the development of both the regional and the national economy. The regions most deeply involved in the process of forming a new economic development trend are identified when at least 80% of the maximum value of this indicator among industrial territories is achieved (Activation).

Step 3. This step is implemented on the basis of a matrix approach to formalizing economic immunity, which makes it possible to provide an integrative assessment of the protective (Protection) and activating (Activation) mechanisms of the economic development of industrial regions.

Results

The author's methodology was tested on the period 2009–2018 using the example of industrial regions, which were divided into two groups: 1) industrial regions with a manufacturing specialization, where the share of manufacturing in GRP is $\geq 25\%$; and 2) industrial regions with a diversified economy.

Step 1 was implemented within two five-year measurement intervals: 2009–2013 and 2014–2018, the choice of which is dictated by the Great Recession of 2008. The systematization of the assessments for all the analyzed factors made it possible to note that the majority of industrially developed regions with a pronounced specialization are sensitive to external economic shocks (*Tab. 2*). The exceptions are the Leningrad Region and the Tula Region, as well as the Republic of Bashkortostan, which have no indicators that fall in the zone of low resistance and low recovery. At the same time, 15% of the regions have one vulnerable factor, 40% have two factors, 25% have three factors, and 5% have

Table 2. Formalization of protective mechanisms in industrial regions with a pronounced specialization

	Region	P	L	Kn	Inv	Techn	Inn	Protection
1	Kaluga Region	I	II	I	II	IV	I	20
2	Tula Region	III	II	III	I	III	I	20
3	Leningrad Region	III	II	III	III	II	I	17.5
4	Lipetsk Region	III	I	II	I	III	IV	17.5
5	Omsk Region	I	II	II	II	IV	I	17.5
6	Republic of Bashkortostan	II	II	III	I	II	III	17.5
7	Vologda Region	III	IV	III	I	III	IV	12.5
8	Krasnoyarsk Territory	IV	I	III	IV	II	II	12.5
9	Murmansk Region	I	IV	II	III	IV	II	12.5
10	Nizhny Novgorod Region	IV	IV	III	II	III	I	12.5
11	Arkhangelsk Region	II	III	IV	II	IV	II	10
12	Kirov Region	III	IV	III	IV	II	III	10
13	Novgorod Region	IV	II	IV	I	III	IV	10
14	Perm Territory	IV	II	II	IV	II	III	10
15	Ryazan Region	II	IV	III	II	IV	III	10
16	Chelyabinsk Region	III	I	III	IV	IV	IV	10
17	Vladimir Region	I	IV	IV	IV	IV	II	7.5
18	Sverdlovsk Region	II	IV	II	IV	IV	III	7.5
19	Chuvash Republic	IV	IV	IV	II	III	III	7.5
20	Yaroslavl Region	III	IV	III	IV	IV	III	7.5

Source: own calculations based on open statistical data from <https://rosstat.gov.ru/>.

four factors (Vladimir Region), which undermine the territories' economic immunity.

As for industrial regions with a diversified economy, they also proved to be sensitive to external shocks. At the same time, the Voronezh, Novosibirsk, and Tyumen regions, the Republic of Tatarstan, and Saint Petersburg have no indicators that fall in the zone of low resistance and low recovery (*Tab. 3*). 32% of the regions have one

vulnerable factor, 32% have two factors, and 12.5% (the Ivanovo Region and the Komi Republic) have three factors that undermine their economic immunity.

Moreover, a structural breakdown of the protective mechanisms makes it possible to identify the indicators of industrial regions that are most sensitive to shocks, depending on the type of region (*Fig. 2*).

Table 3. Formalization of protective mechanisms in industrial regions with a diversified economy

	Region	P	L	Kn	Inv	Techn	Inn	Protection
1	Republic of Tatarstan	I	I	I	II	I	III	25
2	Novosibirsk Region	I	I	II	II	III	I	22.5
3	Voronezh Region	I	III	I	II	III	III	20
4	Tyumen Region	II	II	I	I	II	III	20
5	Kursk Region	II	IV	I	III	II	I	17.5
6	Tomsk Region	II	I	III	IV	II	I	17.5
7	Belgorod Region	I	II	II	IV	III	III	15
8	Irkutsk Region	IV	IV	II	I	III	I	15
9	Moscow Region	IV	III	I	III	II	III	15
10	Primorye Territory	II	I	IV	II	III	III	15
11	Kemerovo Region	III	IV	IV	I	III	III	12.5
12	Ulyanovsk Region	III	IV	III	II	I	IV	12.5
13	Volgograd Region	III	III	II	IV	IV	III	10
14	Ivanovo Region	II	IV	I	IV	IV	III	10
15	Samara Region	IV	II	II	II	II	IV	10
16	Komi Republic	II	IV	IV	II	III	IV	7.5

Source: own calculations based on open statistical data from <https://rosstat.gov.ru/>.

Figure 2. Structural matrix of protective mechanisms in industrial regions

Industrial regions with a manufacturing specialization						Industrial regions with a diversified economy				
	I	II	III	IV	Protection	I	II	III	IV	Protection
P	4	4	7	5	47.5	4	6	3	3	42.5
L	3	7	1	9	35	4	3	3	6	35
Kn	1	5	9	5	40	6	4	2	3	45
Inv	5	6	2	7	45	3	7	2	4	37.5
Inn	5	4	7	4	52.5	4	0	9	3	40
Techn	0	5	6	9	27.5	2	5	7	2	42.5
$\overline{Protection} = \frac{1}{n} * \sum Protection_{P/L/Kn/Inv/Inn/Techn},$ where n is the number of regions in the corresponding group										
$\overline{Protection} = 12.4$						$\overline{Protection} = 15.1$				

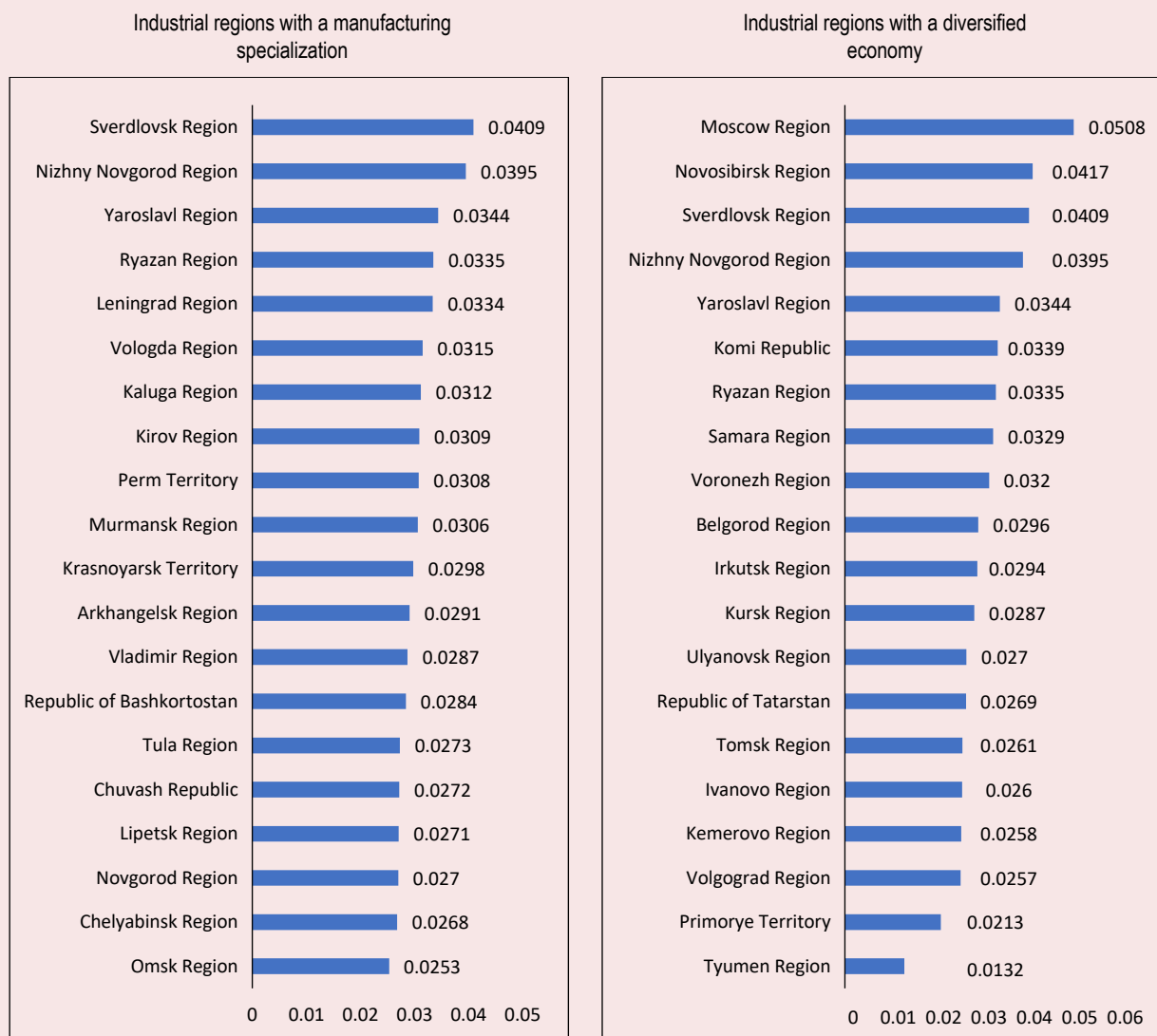
Source: own calculations based on open statistical data from <https://rosstat.gov.ru/>.

The matrix obtained demonstrates that, during periods of external shocks, the most alarming indicators for industrially developed regions are the average annual number of persons employed in manufacturing and expenditure on technological innovation. For industrial regions with a diversified economy, the most alarming indicators are investment in fixed assets and the average annual number of persons employed in manufacturing.

On average, industrial regions with a manufacturing specialization prove to be less ($\overline{Protection} = 12.4$), than regions with a diversified economy ($\overline{Protection} = 15.1$), which calls for more substantial preventive measures.

Step 2 of the study was carried out over the period 2018–2025. The results of the narrative express analysis point to variation across regions in their predisposition to participate in the genesis of a new economic development trend (Fig. 3).

Figure 3. Ranking of industrial regions by predisposition to participate in the genesis of a new economic development trend, activation



Source: own calculations based on open statistical data from Yandex Wordstat (<https://wordstat.yandex.ru/>) and Rosstat (<https://rosstat.gov.ru/>).

Thus, looking at the indicator reflecting the presence of the sought-after narrative in the collective memory – confirming the activation of the economic immunity mechanism – per employed person, a greater involvement in shaping the new code of economic transformation is recorded for regions with weaker protective mechanisms (regions with a manufacturing specialization) than for regions with a diversified economy, which possess stronger protective mechanisms: the group averages are 0.031 and 0.029, respectively. The leaders in terms of inclusion in the genesis of a new economic development trend are the Moscow, Novosibirsk, and Sverdlovsk regions; the ranking's outsiders are the Tyumen and Omsk regions.

In Step 3, the matrix-based approach to formalizing economic immunity makes it possible to identify regions that possess strong, vulnerable, and undermining characteristics of such immunity (Fig. 4).

The greatest economic immunity is exhibited by the Novosibirsk Region; the Moscow Region and the Republic of Tatarstan rank second. Fifty percent of the industrial regions possess vulnerable economic immunity (of these, 44% are constituent entities with a diversified economy), while 36%

of the regions have an undermining protective mechanism and a vulnerable activating mechanism (of these, 23% are entities with a diversified economy). At the same time, the Sverdlovsk Region has an undermining protective mechanism that enables the region to participate more fully in the processes of shaping a new economic development trend. The Tyumen Region has the weakest economic immunity, which accounts for the territory's vulnerability and weak adaptability to external crisis phenomena.

On the whole, the matrix-based approach makes it possible to register the presence in society of the prerequisites for shaping a new code of economic development. Moreover, these prerequisites correlate positively with the share of employed persons holding higher education, yet they are not connected with, nor do they determine, the rate of GRP growth. Consequently, it is necessary to transform these prerequisites into effective mechanisms of economic development – that is, to strengthen the activating function of the protective mechanism of industrial regions' immunity.

Conclusion

As a result of the study, a methodological approach to formalizing the economic immunity of industrial

Figure 4. Formalizing the economic immunity of industrial regions

Protective mechanism of economic immunity (Protection)	Strong		Republic of Tatarstan	Novosibirsk Region
	Vulnerable	Tyumen Region	Belgorod Region; Vologda Region; Voronezh Region; Irkutsk Region; Kaluga Region; Kemerovo Region; Krasnoyarsk Territory; Kursk Region; Leningrad Region; Lipetsk Region; Murmansk Region; Nizhny Novgorod Region; Omsk Region; Primorye Territory; Republic of Bashkortostan; Tomsk Region; Tula Region; Ulyanovsk Region	Moscow Region
	Undermining		Arkhangelsk Region; Vladimir Region; Volgograd Region; Ivanovo Region; Kirov Region; Novgorod Region; Perm Territory; Komi Republic; Ryazan Region; Samara Region; Chelyabinsk Region; Chuvash Republic; Yaroslavl Region	Sverdlovsk Region
		Undermining	Vulnerable	Strong
Activating mechanism of economic immunity (Activation)				

Source: own calculations.

regions has been developed, the relevance of which stems from the multidimensionality of the methods used to assess the shock resilience of territories – methods that depend on spatial and temporal factors (Chen et al., 2024; Sutton et al., 2023) yet focus solely on the protective mechanisms of economic development.

The cornerstone of the author's approach is a matrix that integrates the findings from two sources: first, the application of an evaluation toolkit that assesses industrial regions' predisposition toward economic resistance and recovery, which determines the functioning of their protective mechanisms against external shocks; and second, a narrative express analysis that reveals the prerequisites for the genesis of a new technological trend in economic development under new economic conditions, which accounts for the territories' adaptation to them. This methodological approach advances the ideas behind measuring regional shock resilience by expanding the content of the concept of "economic immunity" – through the inclusion of an additional factor dimension, namely territorial predispositions – and thereby endows the concept with characteristics of adaptability and dynamism.

The testing of the matrix-based approach within the framework of the study made it possible to identify a greater degree of economic protection in industrial regions with a diversified economy than in those with a manufacturing specialization.

This confirms the enduring importance of expanding the sectoral specialization of territories, including through innovation and digitalization. Implementing these preventive measures during non-crisis periods will minimize the risks of a decline in the adoption of technological innovations and of slow recovery in the face of shocks, as was observed in 29% of regions during the 2008 crisis, when only 8% of industrial regions proved positively resilient in terms of the dynamics of spending on innovative technologies, while 61% of territories saw their innovation activity generally trending downward amid the shock disturbances.

This can be achieved by activating the regions' existing predisposition toward economic transformation – namely, by defining a "condensed set of rules that incorporate what is consensual and successfully operative within the existing socio-cultural code of the region's economic development" (Brockmeier, Harré, 2000), by interpreting economic-political events, and by outlining the directions of their technological solutions (Shiller, 2019a; Angulo et al., 2018).

Thus, taking into account the heredity of regions will make it possible to formalize economic immunity not only for designing subsequent measures to ensure the shock resilience of territories, but also for fostering the evolutionary character of development at both the regional and the national level.

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Received March 23, 2026.