REVISTA RELAÇÕES INTERNACIONAIS DO MUNDO ATUAL

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MODELING OF SUSTAINABLE DEVELOPMENT PROCESSES OF ENTREPRENEURIAL ECOSYSTEM IN THE CONTEXT OF BIOLOGICAL THREATS BASED ON THE EXAMPLE OF YUGRA

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ABSTRACT

Objective: This article presents a comprehensive model for assessing the resilience of regional business ecosystems with a specific focus on the Khanty-Mansiysk Autonomous Region (Yugra), Russia. **Methods:** The study incorporates various parameters to evaluate the resilience and development potential of the entrepreneurial environment in the face of biological threats, such as the COVID-19 pandemic. Methodologically, the authors use a multi-stage calculation process normalizing regional indicators and assessing them relative to the maximum values for the Russian Federation. **Results:** The outcomes indicate that the entrepreneurial ecosystem of Yugra is currently at a satisfactory level of sustainability. However, critical areas for further improvement include developing networks, talent and knowledge acquisition, developing leadership skills, and adopting Industry 4.0 technologies. **Conclusion:** The present research provides valuable insights into the specific challenges and opportunities facing regional business ecosystems in the context of biological crises and emphasizes the importance of addressing these challenges to enhance economic resilience and growth. The implications of this study underscore the need for targeted interventions to bolster Yugra's entrepreneurial ecosystem. Strategies should focus on enhancing networking, nurturing local talents, promoting innovation, and facilitating the adoption of advanced technologies. By addressing these critical areas, regional authorities and stakeholders can better position Yugra to thrive in the face of future biological threats and foster sustainable economic development.

Keywords: Entrepreneurial ecosystem; Northern region; Biological threats; Coronavirus; Resilience.

MODELAGEM DE PROCESSOS DE DESENVOLVIMENTO SUSTENTÁVEL DE ECOSSISTEMAS EMPRESARIAIS NO CONTEXTO DE AMEAÇAS BIOLÓGICAS COM BASE NO EXEMPLO DE YUGRA

RESUMO

Objetivo: Este artigo apresenta um modelo abrangente para avaliar a resiliência dos ecossistemas empresariais regionais com foco específico na Região Autônoma de Khanty-Mansiysk (Yugra), na Rússia. **Métodos:** O estudo incorpora vários parâmetros para avaliar a resiliência e o potencial de desenvolvimento do ambiente empreendedor diante de ameaças biológicas, como a pandemia de COVID-19. Metodologicamente, os autores utilizam um processo de cálculo em várias etapas, normalizando os indicadores regionais e avaliando-os em relação aos valores máximos para a Federação Russa. **Resultados:** Os resultados indicam que o ecossistema empreendedor de Yugra está atualmente em um nível satisfatório de sustentabilidade. No entanto, as áreas críticas para melhorias adicionais incluem o desenvolvimento de redes, a aquisição de talentos e conhecimentos, o desenvolvimento de competências de liderança e a adoção de tecnologias da Indústria 4.0. **Conclusão:** A presente investigação fornece informações valiosas sobre os desafios e oportunidades específicos enfrentados pelos ecossistemas empresariais regionais no contexto de crises biológicas e enfatiza a importância de enfrentar estes desafios para aumentar a resiliência económica e o crescimento. As implicações deste estudo sublinham a necessidade de intervenções direcionadas para reforçar o ecossistema empreendedor da Yugra. As estratégias devem centrar-se no reforço do networking, no cultivo de talentos locais, na promoção da inovação e na facilitação da adopção de tecnologias avançadas. Ao abordar estas áreas críticas, as autoridades regionais e as partes interessadas podem posicionar melhor a Yugra para prosperar face a futuras ameaças biológicas e promover o desenvolvimento económico sustentável.

Palavras-chave: Ecossistema empresarial; Região norte; Ameaças biológicas; Coronavírus; Resiliência.

1 INTRODUCTION

The coronavirus pandemic has become a major shock that resulted in hard times for the economies of all countries. Threats of losing human lives left all levels of government with an extremely narrow set of maneuvering options to keep the socio-economic performance of their regions at an acceptable level. The same dilemma has confronted entrepreneurs. Their options for choosing the optimal strategy came down to such possibilities as staffing cuts, refusal to provide services, search for investments for the implementation of digital technologies, and new business streams.

In this regard, of research interest are ecosystems at the regional level, where governing bodies have levers for operational control and management of the situation and the ability to consolidate and coordinate local economic actors and institutions that influence entrepreneurial potential. According to L. Lafuente, Z. Ács, and L. Szerb (2022), opportunities to improve the entrepreneurial ecosystem are hidden in the

understanding of geographical heterogeneity, complexity, multidimensionality, and interrelationships between all stakeholders and available localized resources of territories.

Besides, the issue of biological crises is not irrelevant. Traditional macroeconomic thinking points to the temporary nature of external crises and economic downturns, following which the economy recovers its growth potential and the working population returns back to their jobs (Brada et al., 2021). Specialists warn that viral epidemics are regularly occurring in global space, which is becoming a real catastrophe for humanity and its prosperous existence. Only for the last century, the world has experienced a range of major viral epidemics, such as Spanish flu, SARS, avian flu, swine flu, Ebola fever, and others (Shirokova, 2022). Therefore, it can be assumed that mankind will have to face such a challenge again in the future.

Each country has its own vulnerabilities and none of the surveyed countries are characterized by a high level of preparedness to cope with the global pandemic threat (Coccia, 2022). For this reason, researchers in many countries state the importance of increased flexibility and resilience for small businesses and government agencies during biological crises, the need for timely risk analysis, business resilience planning, cross-border digital trade, and robust digital communication between business and government (Engidaw, 2022). Moreover, external disruptions like COVID-19 can create additional incentives for experimenting and learning how to conduct business in new extreme environments focusing on organizational resilience, including reconfiguring in-house resources and network environment (Simms et al., 2022; Simonen et al., 2021).

Given the vastness and diversity of Russian territories, the northern regions deserve special attention. Such territories are characterized by severe natural conditions, limited activity of the population, high cost of production and living, and dependence on supplies of food, fuel, and various products (Tishkov et al., 2022). Rapid comprehension and acceptance of the healthcare crisis, inventory of available tools, timely adaptation, and organizational flexibility without suitable retrospective experience allow many small companies to survive the crisis (Sarkar and Clegg, 2021). In turn, understanding regional features in enterprise performance management during the COVID-19 pandemic, which may act as advantages or bottlenecks during the crisis period, will help in creating specific management mechanisms to overcome undesirable consequences (Kuvalin et al., 2022). To create the necessary tools and

variation mechanisms of regulation, the development of a set of parameters for simulating the processes that ensure the sustainable development of the entrepreneurial ecosystem exposed to biological threats becomes relevant. In the present research, this problem is studied based on the example of the northern subject of Khanty-Mansiysk Autonomous Region – Yugra.

Yugra is a constituent region located in the zone of sharp continental climate. The period with stable snow cover takes up to 200 days a year and night frosts may occur in summer in areas of local depressions. The harsh climate has affected the settlement pattern of the region's inhabitants. According to Rosstat, the population of Yugra is 1.7 mln people (Federal State Statistics Service, 2021), with a population density of 3.13 people/km^2 (for comparison, the average population density in Russia in 2020 was 8.57 people/km²). The share of the urban population in the region amounts to 92.51%. The administrative center of the Region is the city of Khanty-Mansiysk, another largest city is Surgut.

Yugra is not only a prosperous region in socio-economic terms but also a donor region. The region's high potential is ensured by a pronounced fuel and energy component not only in the Russian but also in the global economy: thus, up to 70% of the entire territory of Yugra is promising in terms of natural resources extraction. Before the pandemic, Yugra produced about 43% of Russian oil and about 5.4% of gas (Utyusheva & Takmasheva, 2020).

The region has no external borders and is connected with other regions by water and rail transport (which accounts for up to 69% of all freight and goods transportation). Road transport accounts for 29%. Small aircraft (small planes, helicopters) are used to communicate with indigenous peoples living in remote settlements, as well as to perform other functions of transport logistics.

2 LITERATURE REVIEW

For a more comprehensive and in-depth understanding of the issues and methods to ensure sustainable development of the entrepreneurial ecosystem in the context of biological threats, publications dealing with regional practices in overcoming the consequences of the COVID-19 pandemic for local businesses were studied.

Based on a sociological survey, O.N. Konovalova and A.V. Lukash (2022) consider two main strategies of business community behavior:

1. preserving the maximum level of available resources and economic indicators by reducing marketing and investment costs;
2. searching for new opportunities and new types and methods of doing business through the development of marketing, investment, and digital tools.

Confirmation of the impact of the epidemiological situation on consumer behavior, services, and resilience of the regional economy based on the econometric model is noted in the works by A.V. Pecherina (2022).

The systematization of the anti-crisis policy practice for the Southern Federal District regions in the context of coronavirus characterized by following the regulations of the central authorities and the priority of saving lives over economic indicators was carried out by A.E. Kalinina, I.V. Mitrofanova, and O.A. Chernova (2022).

To form a proper scientific and methodological toolkit for simulating the processes ensuring sustainable development of entrepreneurial ecosystems influenced by biological threats considering the example of Yugra, we studied publications devoted to the urgent problems of economic development of the northern regions of Russia.

N.E. Egorov et al. (2022) conclude that the digitalization level of resource-type northern regions is higher than the all-Russian one. Thus, the high potential of digitalization can be used to ensure the innovative development of such territories.

The lack of spatial development strategy in northern regions in the context of localization and communication compression is described by S.S. Patrakova (2022). The author includes in the list of practical guidelines benchmarking experience in the management of spatial and innovative development of northern regions.

The relationship between the consequences of the pandemic of a new coronavirus infection and economic security for the northern regions of Russia is shown by E.A. Shirokova (2022) in the context of the Magadan Region. In this study, the researcher considers the key indicators of economic and social security.

The results of a large content analysis based on 477 research documents and publications on the impact of the COVID-19 crisis on business are provided by M.M. Alshater, O.F. Atayah, and A. Khan (2022). The authors group the publications on global economic issues, emphasizing 1) business and management; 2) financial markets; 3) tourism implications; 4) supply chains; and 5) tourism functionality.

The complex issue of the interaction between business ethics and irrationality in business during the crisis caused by the coronavirus pandemic is addressed by X. Huang, K.Y. Chau, Y.M. Tang, and W. Iqbal (2022) based on the example of Chinese

companies. The authors conclude that during the pandemic, small and medium-sized enterprise owners were not fully driven by commercial objectives but also considered moral principles embedded in business ethics. The authors recommend cultivating the values of responsible business ethics through free public training programs.

The results of simulating the risks of long-term supply chain disruptions under the impact of short- and long-term pandemic waves are presented by D. Ivanov (2020). The simulation model allows for calculating the supply chain recovery time after a pandemic, the scale and timing of supply chain support at the time of critical disruptions, and possible scenarios of epidemic spread.

Many works are devoted to the regional resilience of enterprises and economic systems. X. Hu, L. Li, and K. Dong (2022) report that the resilience of the regional economy, as shown by the old industrial areas of China, depends not only on structural factors but also on the targeted efforts of the authorities. In turn, the high openness of the economy and the high share of secondary and tertiary sectors reduce the region's ability to resist.

The analysis of stability to the global financial crisis of the Central and Eastern European countries (Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, and Slovakia) by J.C. Brada, P. Gajewski, and A.M. Kutan (2021) leads to the idea that interregional differentiation contributes to forming different clusters based on similar attributes. Clusters of low-performing regions in times of crisis can become sources of unrest. In this regard, authorities should put efforts to reduce interregional socioeconomic differences.

Considering the US as an example, A. Kim, J. Lim, and A. Colletta (2023) find that during pandemic shocks, economies with a dominant primary industry with low levels of interpersonal interaction are more resilient; in turn, state (regional) economies with industries with high levels of interpersonal interaction are more vulnerable to social distancing.

S. Tuysuz, T. Baycan, and F. Altuğ (2022) conclude that Turkish regions with innovation and export potential were more sensitive to the impact of the pandemic crisis; regions with large businesses are more resilient. The authors point out that these results are either consistent or inconsistent with the findings of other studies. This indicates the complexity and multifactorial nature of a global economic problem such as a pandemic.

J. Brzyska and I. Szamrej-Baran (2021) focus on interregional differentiation. In the

course of cluster analysis, 27 countries of the European Union were divided into four groups according to the degree of resilience. The strongest group was represented by Germany, the Netherlands, and Ireland with the best health care system and innovation, while the weakest group was represented by Southern European countries (Italy, Greece, Spain, Portugal, and Croatia) characterized by aging populations and poor health care.

To analyze the resilience of African countries in the face of uncertainty and unpredictability of external global changes, J. Rockström et al. (2023) use five attributes: diversity, redundancy, connectedness, inclusion, equality, and adaptive learning. Additionally, to enhance the scalability of ongoing resilience efforts, the authors consider three principles: 1) restructuring financial and economic systems; 2) rethinking knowledge creation and use; and 3) reconnecting people with nature.

A special block of the present research concernes close examination of publications devoted to the construction of regional entrepreneurial ecosystem concepts and models. Considering the entrepreneurial ecosystem from the spatial viewpoint, S. Schäfer (2021) concludes that the study of territories based on administrative boundaries is often inaccurate. New approaches to assessing spatiality through the study of the geophysical concentration of firms, economic actors, and networks, as well as the links between them, are needed.

The main conclusion of P. Muñoz, E. Kibler, V. Mandakovic, and J. Amorós (2022) is that there is no single approach to entrepreneurship management at the local level. Often, even one region can include different spatial configurations, organizations, and localizations of entrepreneurial ecosystems, which must be considered when designing and implementing public policies.

Considering the analysis of the reviewed works in the field of economics, it is necessary to note the high relevance of studying the resilience of regional entrepreneurial ecosystems exposed to biological threats.

3 METHODS

Standard methods of data collection and processing were used to conduct the research, including:

1. content analysis of information resources and materials;

2. statistical analysis of socio-economic indicators, characterizing the resilience of the entrepreneurial ecosystem in the region.

Official statistical data, reports, and information resources of government services and agencies and materials of scientific institutions and independent Russian rating agencies were used as sources.

The methodology used in this study aims to assess the resilience of regional business ecosystems in Russia, focusing on the Khanty-Mansiysk Autonomous Region – Yugra. To achieve this goal, a multi-stage calculation process was undertaken. Firstly, a wide range of parameters was selected to characterize the entrepreneurial environment, including formal institutions, the resilience of entrepreneurship, network development, physical infrastructure, digital infrastructure, financial stability, talents, new knowledge, demand, intermediate services, development of the regional resource and raw material potential, migration processes, spatial density of service sector entities, environmental behavior, leadership, and Industry 4.0 adoption. Each parameter was normalized by calculating the ratio of the regional indicator for Yugra to the maximum value among Russian regions during the study period. For parameters, where binary values were applicable, such as leadership and Industry 4.0 implementation, a simple "Yes" or "No" rating was used. The resulting normalized values for each parameter were then averaged to obtain an overall resilience index for the Yugra entrepreneurial ecosystem. This index was interpreted according to a rating scale ranging from *low* to *high* levels of resilience. The methodology also relied on various data sources, including official statistics from Rosstat, federal service directories, and regional reports. These data sources were meticulously referenced to ensure transparency and reproducibility of the findings.

4 RESULTS AND DISCUSSION

The following principles served as starting points for building a model to describe the processes ensuring the resilience of the entrepreneurial ecosystem:

- simplicity and convenience of index calculation;
- possibility of considering territorial and socio-economic problems in the region;
- possibility of measuring the resistance potential of the regional business ecosystem during a biological crisis caused by a pandemic.

Three parameter blocks were used to build a model of entrepreneurial ecosystem

resilience:

1. General (universal) parameters, which in general can characterize the status of the ecosystem for any region;
2. Parameters for the northern regions, reflecting the problems characteristic of the northern territories;
3. Parameters describing regional conditions for providing resilience of the entrepreneurial ecosystem in a situation of biological crisis.

In total, 16 parameters and measurable indicators are involved in the model.

The basic model, which initiated the conducted simulation, was presented in the work by J. Leendertse, M. Schrijvers, and E. Stam (2022) who propose a tool for determining an entrepreneurial ecosystem index for European regions based on ten parameters. According to the authors, the main outcome of the entrepreneurial ecosystem is the growth of output and the number of innovative companies. The researchers detail the essence and meaning of the parameters also used and adapted in the present work to analyze the general block in relation to the specifics of the Russian region. The concerned block of parameters includes the main indicators reflecting the functioning of the entrepreneurial ecosystem and describing its ability to support and develop innovation, provide access to financial resources, support demand (which is also important in the crisis period), provide digital and transportation communication, render the required scope of business services, and ensure business activity of enterprises. Since the novelty of the proposed model consists in the consideration of the regional and biological aspects, it is necessary to justify the indicators that were introduced.

One of the key characteristics of the northern regions is the concentration of a huge amount of natural resources, which has determined the raw-material-based model of the local economy. The exploitation of natural minerals, forests, and energy potential has led to the exhaustion of the reproductive capacity of the territories. On the other hand, a trend toward innovative development is emerging at the national level. Preserving the regional raw-material-based model of the economy of the northern territories limited in the strategic perspective and forming a new innovation landscape in the European and southern parts of the country can lead to an even greater gap between the constituent entities of the Russian Federation and the more difficult integration process of the former into the economic and business ties of the whole country and its individual regions. The category of resource-type northern regions

concerns territories with a high share (more than 30%) of mining operations as the type of economic activity in the industry of a region or a constituent entity of the Russian Federation (Gulyaev, 2019).

According to S.V. Tishkov, N.E. Egorov, and A.D. Volkov (2022), one of the promising economic growth lines in the northern regions is creating innovative industrial clusters based on advanced mineral resource centers and existing industries. This circumstance prompted us to include in the model the indicator reflecting the development of regional resource and raw material potential of territories described based on relevant infrastructure facilities. Using a mobilization approach to economic development and considering the increasing role of the natural factor, V.N. Lazhentsev (2022) proposes developing the northern territories based on the economy deepening principle instead of the widely spread economy widening principle. Recent studies have addressed various aspects of sustainable development, such as the impact of Geographical Indications (Malaguti & Avrichir, 2023), the influence of environmental concern on Green Purchasing Dynamic Capabilities (Tondolo et al., 2023), and corporate responses to Corporate Social Responsibility during the COVID-19 pandemic (Madaan, Kaur & Gowda, 2023).

Besides the diversity of natural resources, the northern territories are characterized by severe climatic conditions. Critically low temperatures, long duration of winter, high cost of living, and long distances to southern regions and summer vacation destinations provoke the outflow of the local population. Such conditions create a lack of human capital. On the scale of global, national, and interregional competition for talented specialists, the northern regions remain unattractive to the economically active population. The shortage of highly qualified personnel negatively affects the level of innovative development, hinders the creation of new industries, generates new knowledge and technologies, and forms a variety of local service economies for businesses and the population (Lazhentsev, 2022). Therefore, the parameter for assessing migration flows in the region is one of the descriptive features of the regional entrepreneurial ecosystem.

The severity of the climate and vast underdeveloped territories also determine the specifics of settlement and location of economic entities. Given the low population density of the northern regions, it is assumed that the density of economic entities is also low. Developing further the networking problem considered by J. Leendertse, M. Schrijvers, and E. Stam (2022) as a necessary condition for generating new knowledge

and creating products with high added value, we consider it necessary to include in consideration a special parameter, namely the physical density of economic entities. On the other hand, the introduction of such an indicator will allow an understanding of the physical characteristics of the business environment of the enterprise, which incorporates suppliers, customers, and partners.

In the crisis period, the quality and quantity of interconnections and relationships in the business environment serve as a factor contributing to business resilience and survival.

Thus, the spatial concentration of enterprises can determine both the form of the ecosystem and the range that supports the interaction processes within the enterprise ecosystem boundaries based on the forest concept. A tropical forest conceptual model for the business ecosystem is proposed by A. O'Connor and D. Audretsch (2023). The essence of this concept is considering the climatic zone of the forest, the diversity of species, the height and density of trees, and the diversity of organic and inorganic interrelations. The listed circumstances are the reason for including in the model such a parameter for the northern region as the spatial density of the service sector entities. Considering the economic and geographical specifics of the northern regions, researchers emphasize the stabilizing power of the public sector and its ability to support the service sector, which is important for the inhabitants of the northern regions.

In the context of the unpredictability of the scale and nature of the consequences, the need for rapid response and adaptation to new biosocial conditions ensuring at the same time preservation of human lives the factor of personal characteristics and abilities of company managers comes to the forefront from the perspective of successful entrepreneurship. Given that, many processes and services are moving at present into the digital space, however, not all categories of employees are ready to work in the new format. Therefore, the leadership skills of an entrepreneur play one of the defining roles in the resilience of small-scale businesses in an extreme situation. The importance and community demand for leadership skills in the era of business space virtualization as an inevitability in a period of forced social distancing is pointed out by R.X. Thambusamy and Z. Bekiroğulları (2020). Skills, such as organizing virtual space and new communication protocols ensuring that online platforms are usable by all employees and maintaining a company's strategic goals, are integral factors in the resilience of small businesses.

The consideration of leadership as one of the resilience and enterprise viability parameters is included in the resilience assessment of entrepreneurial ecosystems in European countries by J. Leendertse, M. Schrijvers, and E. Stam (2022) where leaders are defined as actors playing a leading role in the ecosystem. To measure this aspect, E. Stam, and A. Van de Ven (2021) propose to use the number of innovation project leaders as an indicator. Given the lack of a universal and transparent approach to accounting for this parameter with regard to Russian regions, it was proposed to use the availability of educational programs on the development of leadership skills as a parameter. When elaborating on the importance of leadership for business during biological crises, the work by E. Hadjielias, M. Christofi, and S. Tarba (2022) deserves particular interest. This study is devoted to the psychological resistance of business leaders as a factor and resource of the organizational resilience of an enterprise.

The biological crisis caused by the coronavirus pandemic has required mobilizing all resources. Considering the environmental factor of regional ecosystem resilience remains important. As J. Sheth (2020) emphasizes, COVID-19 manifested the existing interdependence between government, business, and the local community. During the pandemic, greater viability among industrial enterprises was demonstrated by those companies that were beyond pursuing purely commercial goals, building relationships based on trust, reliability, green behavior, and the preservation of mutually beneficial interests.

For example, air quality improved in cities where the subway was stopped. Thus, the reduction of carbon footprint, preservation of biodiversity, and reduction of the aggressive anthropogenic impact on nature are integral parameters of the resilience of the regional entrepreneurial ecosystem (O'Connor & Audretsch, 2023). Considering this, the parameter of environmental behavior was included in the considered model. In the context of sustainable development of entrepreneurial ecosystems and biological threats, the work by R. Panwar, H. Ober, and J. Pinkse (2022) deserves special attention. This study is devoted to commercial drivers of biodiversity reduction, which include land use, pollution, artificial implementation of biological species into the established ecosystem (agroforestry, forestry, ornamental horticulture), overexploitation of resources, and climate change.

In the context of the pandemic, it became necessary to reduce social contacts; industries and companies that could not continue their production with minimized contacts suffered great losses. In light of increasing the resilience of regional

ecosystems, the development of Industry 4.0 technologies, which is based on the application of large-scale machine-to-machine communication (M2M), the Internet of Things (IoT), and the industrial Internet of Things (IIoT) without human intervention, is of particular relevance. The beneficial effect of Industry 4.0 technologies on the resilience of the circular economy is proven by Y. M. Tang, K. Y. Chau, A. Fatima, and M. Waqas (2022) in their case study of Indian companies. These technologies have contributed to reducing carbon footprint, improving operational performance, reducing pollution and resource consumption, and increasing operational efficiency and environmental performance. For example, effective solutions based on the implementation of big data technologies were successfully implemented during the COVID-19 pandemic in Moscow, Russia, when new approaches to public administration had to be proposed in an extremely short period of time. These circumstances served as the reason for introducing the Industry 4.0 indicator into the proposed model (Table 1). The prospects, key actors, successful practices, and resource base of using big data technology as an integral part of government support for business during the coronavirus pandemic were analyzed by A.N. Shcherbak and S.A. Shmeleva (2022) based on the example of Moscow, the Moscow region, and St. Petersburg. Advanced technologies, digital skills, and digital transformation of the business environment and local government bodies provide additional opportunities not just for the survival of businesses but also for the inclusive and equitable recovery of the business ecosystem. This is the conclusion drawn by K. Mossberger, N.F. Martini, M. McCullough, and S. Tolbert (2023).

Table 1. Parameters of the resilience model of the regional entrepreneurial ecosystem

No.	Parameter under study	Description	Suitable empirical indicators for Russian regions
1	Formal institutions	Characterization of regional government efficiency	Rating of public administration efficiency in the constituent entities of the Russian Federation
2	Resilience of entrepreneurship	Ability of business to withstand external threats	Ratio of the number of active enterprises to the number of fading enterprises
3	Network development	Regional connectivity of enterprises to create new value	Share of products of high-tech and knowledge-intensive industries in the gross regional product* (in current prices, percent)
4	Physical infrastructure	Transportation infrastructure as a factor of effective economic growth in the regions	Transportation infrastructure index
5	Digital infrastructure	Capacity of the region to	Index of the total score in the rating of

		provide and consume services in the digital space	regions on digital transformation (RRDT)
6	Financial stability	Indicator shows the general level of financial stability of the population, which is especially important in times of crisis	Number of accounts (deposits) of individuals and individual entrepreneurs subject to insurance with a balance of more than one thousand rubles in credit organizations
7	Talents	Predominance of individuals with a high level of human capital	Number of personnel engaged in R&D per 1 mln. population (Rosstat)
8	New knowledge	Investment in new knowledge	Intramural expenditure on R&D as a percentage of gross regional product
9	Demand	Potential market demand, the ability of the regional population to provide an acceptable level of demand	Average per capita income of the population, rubles per month
10	Intermediate services	Supply and availability of intermediate business services in the region	Number of branches of operating credit organizations per one million of the adult population
Parameters for the northern region			
11	Development of regional resource and raw material potential of territories	Innovative and infrastructural support for small businesses contributing to the development of the unique regional resource and raw material potential	Presence of industrial centers for small business support, contributing to the development of the unique regional (local) resource and raw material potential of the territories
12	Migration processes	Reflection of the attractiveness of the region for the population in terms of employment and residence, and preservation of human capital	Migration growth (+) and loss (-) of people per one million population
13	Spatial density of service providers	Regional spatial specificity of territorial distribution density of service economy subjects as a characteristic of spatial resilience of the ecosystem	Number of electronic terminals available at trade (services) organizations (POS-terminals) per 100 thousand km^2
Parameters of biological crisis conditions			
14	Ecological behavior	Ability of the entrepreneurial environment to withstand biological crises at the ecological level	Consolidated ecological index of Russian regions
15	Leadership	Implementation and development of leadership culture and skills in the entrepreneurial environment as a necessary quality in the period of extreme disruptions and uncertainty	Implemented educational programs: availability of educational programs on the leadership issues for existing or burgeoning entrepreneurs
16	Industry 4.0	Ability of the region's entrepreneurship to adapt to external crises and threats due to advanced technologies	Availability of regional centers and Industry 4.0 support programs for small businesses

Source: compiled by the authors

The calculation methodology includes two stages.

At the first stage, each investigated parameter was calculated by finding the ratio of the regional indicator peculiar to Yugra to the maximum value understood as a similar maximum indicator for the given study period in the Russian Federation subjects. The calculation of such ratios should represent a normalized value ranging from 0 (*min*) to 1 (*max*).

In turn, for the three parameters, namely, “Resource and raw material potential”, “Industry 4.0”, and “Leadership skills”, the assessment was made by finding the *Yes* or *No* answer, which corresponded to *1* and *0,* respectively.

The second stage is characterized by finding the arithmetic mean of the index for all the studied parameters. The obtained index can range within the limits from *0* to *1* and be interpreted according to the recommended evaluation scale:

0 – 0.25 – low level;

0.26 – 0.50 – satisfactory level;

0.51 – 0.75 – sufficient level;

0.76 – 1.0 – high level.

The weights of each parameter and each block of indicators are the same. However, we admit that in practice the studied parameters may have different weights and different effects on the efficiency and resilience of the regional entrepreneurial ecosystem depending on the type of region.

The calculation results, presented in Table 2, reflect the resilience index of the entrepreneurial ecosystem of Yugra as being at a satisfactory level (0.40). The enterprises of the region are in a weakly protected environment, and the existing business environment with its infrastructure, potential of internal demand, population, and ecology has insufficient opportunities to stimulate business development at an acceptable level.

Table 2. Calculation of the resilience index of the entrepreneurial ecosystem of Yugra as of 2021

No.	Parameter under study	Calculation model	Calculated value	Data source
		General parameters		
1	Formal institutions	Ratio of regional indicator to the maximum value	0.640 (Yugra)/0.740 (Tyumen Region) = 0.86	IX rating of management efficiency in the constituent entities of the Russian Federation, Agency for Political and Economic Communications, 2021 http://www.apecom.ru/articles/?ELEMENT_ID=7693&sphrase_id=30224
2	Resilience of	Ratio of regional	28.92	Indicators of entrepreneurial activity of

	entrepreneurship	indicator to the maximum value	(Yugra)/48.86 (Kemerovo Region) = 0.59	enterprises by constituent entities of the Russian Federation in 2021 (Rosstat data)
3	Network development	Ratio of regional indicator to the maximum value	4.5 (Yugra)/24.3 (Moscow) = 0.19	Share of products of high-tech and knowledge-intensive industries in the gross regional product* (in current prices, in percent), 2021 Department of the Federal Service for State Statistics for Khanty-Mansiysk Autonomous District https://72.rosstat.gov.ru/ofs_vrphm1 Department of the Federal Service for State Statistics for Moscow https://77.rosstat.gov.ru/folder/134924
4	Physical infrastructure	Ratio of regional indicator to the maximum value	3.80 (Yugra)/8.47 (Moscow) = 0.44	Transportation infrastructure index of Russian regions for 2021 INFRAONE https://infraoneresearch.ru/index_id/2021_regions
5	Digital infrastructure	Ratio of regional indicator to the maximum value	0.20 (Yugra)/0.41 (Belgorod Region) = 0.49	A.H. Kazanbieva (2023) (Data for 2021)
6	Financial stability	Ratio of regional indicator to the maximum value, where max = 1, min = 0	170.8 (Yugra)/5,510.0 (Central Federal District) = 0.03*	Indicators of financial accessibility for 2021. Bank of Russia https://cbr.ru/develop/development_affor/
7	Talents	Ratio of regional indicator to the maximum value, where max = 1, min = 0	559 (Yugra)/15,728 (Moscow) = 0.03	Number of personnel engaged in research and development. Science. Rosstat. 2021. https://rosstat.gov.ru/statistics/science
8	New knowledge	Ratio of regional indicator to the maximum value	0.0004 (Yugra)/0.017 (Moscow) = 0.02	Intramural expenditure on R&D. Science. Rosstat. 2021. https://rosstat.gov.ru/statistics/science
9	Demand	Ratio of regional indicator to the maximum value	62,366.0 (Yugra)/98,364 (Yamalo-Nenets Autonomous District) = 0.63	Income of the population. 2021 Federal Service for State Statistics. http://bi.gks.ru/biportal/contourbi.jsp?allsol=1&solution=Dashboard&project=%2FDashboard%2Fincome_of_population
10	Intermediate services	Ratio of regional indicator to the maximum value	264.2 units (Yugra)/275.7 units (Volga Federal District) = 0.96*	Indicators of financial accessibility for 2021. Bank of Russia. https://cbr.ru/develop/development_affor/
Parameters for the northern region				
	Development of regional resource and raw material potential of	Yes – 1 No – 0	1 (Yugra)	Information portal. Industrial parks of Ugra. https://промпаркиюгры.рф

	territories			
	Migration processes	Ratio of regional indicator to the maximum value	5,335 people (Yugra)/11933 people (Moscow Region) = 0.45	Socio-Economic Situation of Russia, 2021. Federal Service for State Statistics https://gks.ru/bgd/regl/b22_01/Main.htm
	Spatial density of service providers	Ratio of regional indicator to the maximum value	21,014 units (Yugra)/167,840 units (Central Federal District) = 0.13*	Indicators of financial accessibility for 2021. Bank of Russia. https://cbr.ru/develop/development_affor
Parameters of biological crisis conditions				
	Ecological behavior	Ratio of regional indicator to maximum value	51 (Yugra)/77 (Tambov Region) = 0.66	Consolidated Environmental Index of Russian Regions, 2021. Green Patrol. https://зеленыйпатруль.рф/stranica-dlya-obshchego-reytinga
	Leadership	Yes – 1 No – 0	0 (Yugra)	Balance of the work of the Yugra Entrepreneurship Support Fund for 2021-2022. My Business. https://investugra.ru/upload/004/Презентация%20ФМБ.pdf
16	Industry 4.0	Yes – 1 No – 0	0 (Yugra)	Information portal of Yugra Entrepreneurship Support Fund. My Business. https://www.бизнесюгры.рф/fund/general https://www.бизнесюгры.рф/fund/general
Resilience index of Yugra's entrepreneurial ecosystem		Calculation of average value	0.40 (Yugra) satisfactory	Derived from the above data

Source: compiled by the authors
*Data are given based on generalized data on the Federal Districts of Russia.

Drawing practical recommendations for improving the level of sustainable development of the entrepreneurial ecosystem in the context of biological threats requires a detailed consideration of the prerequisites of the obtained index value. The following parameters were the most critical for improving the resilience of the entrepreneurial ecosystem of Yugra:

1) low level of network development, which undesirably affects the intensity of interaction between entrepreneurs, including those needed for creating innovative products;

2) parameters of talent development and generation of new knowledge are also critically low, and here one of the most acute problems of the northern regions of Russia is the lack of highly qualified specialists, who could attract more investments in

the development of the regional scientific and technological base;

3) lack of leadership training programs in the region among implemented training activities for entrepreneurs;

4) no activities are presented at the regional level to support Industry 4.0 technologies.

Among the measures for ensuring the resilience of the entrepreneurial ecosystem, the Khanty-Mansiysk Autonomous District sees the task of developing human capital and talents among the local population, including young people, as well as implementing programs for attracting highly qualified specialists. The latter is relevant and feasible for Yugra because the Region is characterized by a positive migration balance by the end of 2021. The socio-economic situation of the northern oil and gas-producing territories attracts people for resettlement and work.

The region already has a mentoring program, which can become a basis for the popularization and implementation of educational programs on leadership. The leadership development issues have been already included in the list of measures to support small businesses in Russia. Thus, using the special digital platform for small and medium-sized enterprises created with the participation of the government every entrepreneur can test not only their professional competencies but also personal characteristics, including leadership, emotional intelligence, negotiation capabilities, critical thinking, i.e., those personal characteristics of a team and business leader that are especially important in times of large-scale social, economic, and biological upheavals.

The high level of digitalization and the existing infrastructure support centers for industries with a focus on local resource and raw material potential can be used to launch and develop Industry 4.0-based high-tech industries. Impulse industrial technopark of Khanty-Mansiysk offers premises to enterprises for production, repair, and restoration of oil and gas equipment, processing of wild fruits (pine nuts, berries, needles), and testing laboratories for timber products. The industrial park of Nefteyugansk provides premises for companies servicing equipment for oilfield service companies and production of thermal insulation materials. Industry 4.0 technologies are already being implemented in Russian regions by Sibur and Mikran companies in the Tomsk Region, as well as Teplotehnika company in Nizhny Novgorod. The concept of a network factory is presented by the Udmurt machine-building cluster (Ustinova, 2023).

Summarizing the parameters, selected for simulation of the entrepreneurial ecosystem resilience of Yugra, there are several limitations that can be considered in future studies, as well as when developing specific measures at the regional level. Thus, some of the indicators were used and measured with respect to the Ural Federal District relative to another federal district with the maximum indicator value. Since in the model the calculated data related to the highest value of indicator among the constituent entities of the Russian Federation, such relations were often determined with respect to the federal city of Moscow. The overall low resilience index of the entrepreneurial ecosystem at the end of 2021 could be not only due to the devastating impact of the pandemic but also to the pre-crisis state of regional economies, which determines the level of their sensitivity to coronacrisis factors (Kalinina et al., 2022).

5 CONCLUSIONS

To model the processes ensuring sustainable development of the entrepreneurial ecosystem based on the example of Yugra, 16 parameters were used, including standard indicators to describe the entrepreneurial ecosystem, as well as indicators reflecting the features of the northern region and the potential for resilience in the context of biological threats.

As part of the description of regional specifics, the indicators characterizing the resource and raw material potential of territories, migration processes, and spatial density of service sector entities were selected. The list of ecosystem resilience parameters under biological threats includes environmental behavior, leadership, and Industry 4.0 technologies. The presented calculation methodology allows for measuring the entrepreneurial ecosystem resilience index for a given region, which allows for evaluating the level of resilience as low, satisfactory, sufficient, and high.

The obtained calculations characterize the entrepreneurial ecosystem of Yugra as corresponding to the satisfactory level, which indicates the lack of opportunities for qualitative development of the entrepreneurial environment in crisis conditions. The most vulnerable aspects of the studied ecosystem were weak levels of networking, lack of talents and new knowledge, technology development measures for Industry 4.0, and training programs for leadership skills and stress resistance in a turbulent environment. The identified problems can become growth points for the entrepreneurial ecosystem of the northern region.

The presented calculation model can be used by research teams, state and regional governments, managers, and specialists developing specific measures to support and develop entrepreneurial initiatives at the national, regional, and municipal levels.

To develop future research on the resilience of the entrepreneurial ecosystem in the period of biological shocks in the regions of Russia, it is recommended to extend the list of measurable parameters for evaluating the regional and crisis aspects and determine by expertise the weights of the studied parameters depending on the level and development areas of the entrepreneurial environment of the region.

Searching for and accounting parameters of the foreign economic and export activity of small businesses, which also serves as an indicator of the entrepreneurial environment resilience during the pandemic and changing conditions of physical social interaction can be an additional research problem. Evaluating and predicting the performance of an existing or modeled regional ecosystem according to predetermined parameters may become a broader research area in the future.

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