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SMART SPECIALIZING AS KEY DRIVER OF SUSTAINABILITY AND RESILIENCE OF REGIONAL ECONOMY

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ABSTRACT: The purpose of the research is to formulate the proper policy model of identifying regional smart specialisations under conditions of current external risks and the related need to strengthen the resilience of the regional economy. The novel methodology for identifying and supporting sustainable smart specialisations is a significant factor of supporting the resilience of the regional economy. Logical, strategic and statistical analysis methods were used in the research. The main finding of the research is the author's model for identifying smart specialisations, complemented by the resilience criteria for regional economic development. The proposed procedure responds to contemporary external threats, including armed conflicts, accelerating climate change, mass migration, pandemics, and other challenges. The originality of this research is rooted in the development of a policy framework for identifying smart specialisation that fosters both integrated resilience (in the short run) and sustainable development (in the long run). This framework specifically aims to address the gap in current models for formulating regional resilience policies, with a particular focus on enhancing the economic resilience of regions to contemporary external threats.

KEYWORDS: regional development policy, policy model of identifying smart specialisations, resilience of regional economy, sustainable development of the region, external contemporary threats

Introduction

Since 2020, there has been an increased interest in the issues of regional economic resilience policy, both in academia and in development policy makers. This is the result of numerous economic shocks that have affected the global economy over the past few years. These include: financial crises, economic recession, population crises, including migration/refugee movements, the COVID-19 pandemic, aggressive interest rate hikes, broken supply chains, armed conflicts in Ukraine and Israel, food and energy crises. These phenomena (supra-regional, and increasingly often global) are currently the greatest external threats to the development of the European Union regions, including the development of Polish regions.

That is why resilience as a cognitive issue is currently experiencing a renaissance, while there are no proposals for practical solutions to support development policy in the field of resilience at the level of EU regional economies.

The interaction of innovation on the business cycle, including the effects of the economic crisis, is an important and ongoing research topic in the literature (see, e.g.: Schumpeter, 1960; Fiedor, 2009). However, the issue of supporting innovation in the context of improving the resilience of the economy to crises due to external threats is relatively little understood, especially in the application layer.

That is why the following research question was formulated: How to adopt the research innovation strategy for smart specialisations (RIS3) currently used in EU regions to support innovative measures and projects that, at the same time, build the resilience of the economy at this level of development policy?

The main research problem in this context is to find an effective and efficient scheme to support innovation in the broadly understood sphere of economic resilience through the use of smart specialisations in the region's development policy.

The primary aim of this research is to formulate a model for identifying regional specialisations that support the technological and product resilience of the local economy. Additionally, the application goal is to develop a pro-resilience adaptation of the current procedure for identifying regional specialisations, integrating it into the innovation development strategy, with the Opole Voivodeship serving as a case study.

An overview of the literature

The construction of a resilient economy represents a pressing and contemporary issue within both cognitive and utilitarian domains of inquiry. Numerous stakeholders have recognised that the process of economic recovery entails significant risks and challenges, often proving more costly than preventive measures against losses resulting from various threats. Consequently, comprehending regional economic resilience is pivotal for regional policy, which investigates how economic systems can effectively respond to external shocks and promote sustainable development (Martin & Sunley, 2020; Zehui et al., 2023). This imperative for developing resilience-oriented economic policies has emerged as a consensus among policymakers globally (Kass-Hanna et al., 2022).

Notably, the term "resilience" was first introduced in other scientific contexts long before its application in economics. C.S. Holling, an ecologist and pioneer in the concept of resilience, defined it as the overall stability of a system. He differentiated between engineering resilience, which pertains to a system's capacity to swiftly return to its pre-shock state, and ecological resilience, which enables a system to absorb shocks and maintain functionality in a new equilibrium (Holling, 1973). However, both definitions are inherently static and inadequate for capturing the dynamics of socio-economic systems.

In response to these limitations, the notion of adaptive resilience has emerged, describing a system's ability to sustain essential functions while modifying its structure to learn from experiences and "bounce forward." Various academic disciplines, including psychology, engineering, environmental management, and economic geography, have begun to explore the characteristics and ramifications of disruptions (Ostarkova & Stanickova, 2021; Ringwood et al., 2019). The concept of economic resilience gained substantial prominence post-2020 (Masik, 2022; Majchrzak, 2023), as evidenced by documents from institutions such as the OECD (OECD, 2021), the World Bank (World Bank Group,

DOI: 10.34659/eis.2025.93.2.979

2021), the WTO (World Trade Report, 2021), and the European Commission (European Commission, 2020). The 2020 Strategic Foresight Report posits resilience as a new compass for EU policymaking, defining it not merely as the capacity to withstand and manage challenges but also as the ability to undergo transformation in a sustainable, equitable, and democratic manner (European Commission, 2020).

Drawing upon the analysis of the resilience category, we delineate its key attributes within the context of enhancing the resilience of regional developmental capital – namely, improving the safety of residents, mitigating disaster risks, and preventing developmental threats (see: Malik et al., 2024). The approach that promotes strong sustainability of development capital, ensuring that resources are replenished rather than depleted, refers to regenerativity of economy. Our research is focus on fostering this conceptualisation of resilience by supporting pro-innovative measures and developmental projects. Since 2014, innovation development policies within the EU have promoted the cultivation of regional smart specialisations (Malik, 2013a).

Smart specialisations refer to industries and technologies whose advancement is poised to generate innovative socio-economic solutions, augment the added value of the economy, and enhance its competitive edge. This paradigm was introduced through the Europe 2020 Strategy, which advocates for the concentration of resources and efforts on key sectors exhibiting the highest potential for economic growth and innovation. Such an approach enables regions to cultivate unique, endogenous competitive advantages, thereby enhancing their adaptability in the face of global economic challenges. The overarching aim is to achieve elevated levels of employment, efficiency, and social cohesion. In each of these domains, EU member states have articulated their own objectives and developed a series of strategic documents, including the RIS3 (Research and Innovation Strategies for Smart Specialisation) strategies (Szewczuk-Stępień & Klemens, 2019). The smart specialisation framework emphasises research and development-driven growth while leveraging the region's endogenous competitive advantages. Generally, these strategic documents were formulated in accordance with the European Commission's recommendations (European Commission, 2012), which highlighted that the development of a knowledge-based economy necessitates the identification of smart specialisations.

The RIS3 framework continues to play a critical role in fostering sustainable development and enhancing regional economic resilience, effectively integrating various economic theories into policy. A salient example is François Perroux's concept of growth poles (Wojnicka-Sycz, 2020), which suggests that smart specialisations can function as centres attracting investments and innovations to specific economic sectors. This model facilitates the diffusion of benefits to adjacent areas, thereby bolstering their resilience to external shocks, exemplified recently by the COVID-19 pandemic and armed conflicts in Ukraine and Israel. The spatial configuration of growth poles, in relation to smart specialisations as articulated by J.R. Lasuen (Lasuen, 1969) signifies the strategic allocation of key developmental areas that support sustainable growth through inter-city and inter-regional collaboration. Torsten Hägerstrand's theory of innovation diffusion (Guena & Rossi, 2015; Tuziak, 2019) is crucial to the specialisation of regional development, as it allows for the rapid dissemination of new technologies and practices, thereby enhancing regions' adaptability and economic resilience. Concurrently, Milton Friedman's endogenous development theory (Blanchard, 2021) underscores the significance of leveraging a region's internal resources, indicating that investments in human capital, knowledge, and innovation can catalyse sustained economic growth and bolster resilience against external shocks.

Joseph Schumpeter (Sikorska-Wolak et al., 2020; Matysik, 2024) emphasises the role of innovation as a driver of creative destruction within his cyclical economic development theory. In the context of smart specialisations, the support of innovative enterprises can contribute to dynamic economic growth, aiding regions in their adaptation to change. Richard Florida (Kubiciel-Lodzińska et al., 2020) draws attention to the importance of learning regions, which enhance their adaptive capacity by fostering innovation and creativity – critical factors for resilience. Finally, Michael Porter's cluster theory (Kisielnicki & Sobolewska, 2022) illustrates how clusters of interconnected firms and institutions can yield positive externalities to the regional economy. Collaboration within clusters enhances productivity and innovation, thereby contributing to sustainable development and economic resilience. By integrating these diverse theoretical frameworks, smart specialisation characterises dynamic, adaptive economic systems that are better equipped to respond to developmental

DOI: 10.34659/eis.2025.93.2.979

challenges and undergo transformation in a sustainable manner, with all systems continuously learning and responding to evolving realities.

Thus, sustainable development in the context of smart specialisations encompasses desired quantitative and structural transformations of developmental capital. This process arises from the transformation of developmental capitals into new values that are positively evaluated by regional stakeholders (Heffner & Malik, 2011).

Research methods

The significance of supporting innovation in the context of building the economy's resilience to external threats is relatively poorly understood. This is especially true for the application layer, in relation to the use of smart specialisations as a tool of the new resilience policy at the regional level. Below is a comparison of the 'traditional' approach to innovation policy with the contemporary one (Table 1).

Table 1. Comparison of traditional vs. contemporary approaches to innovation policy in building economic resilience

Aspect	Traditional Approach	Contemporary Approach
Objective of Support	Economic growth	Resilience and sustainable development
Scope of Action	National and regional level	Territorial approach
Policy Tools	Grants and subsidies	Smart specialisations in innovations development policy
Type of Intervention	Sectoral intervention	Thematic concentration, ecosystem-level intervention
Success Metrics	Macroeconomic indicators	Resilience and innovation-related macro, mezzo- and micro-indicators
Type of Innovations Supported	Product, process, and organizational innovations	Strengthening the region's smart specialisations
Innovation Support Criteria	Improving financial viability of changes	Improving effectiveness, efficiency and resilience to threats
Business Cycle Modification	Shortening the crisis phase	Extending the growth phase and flattening the business cycle

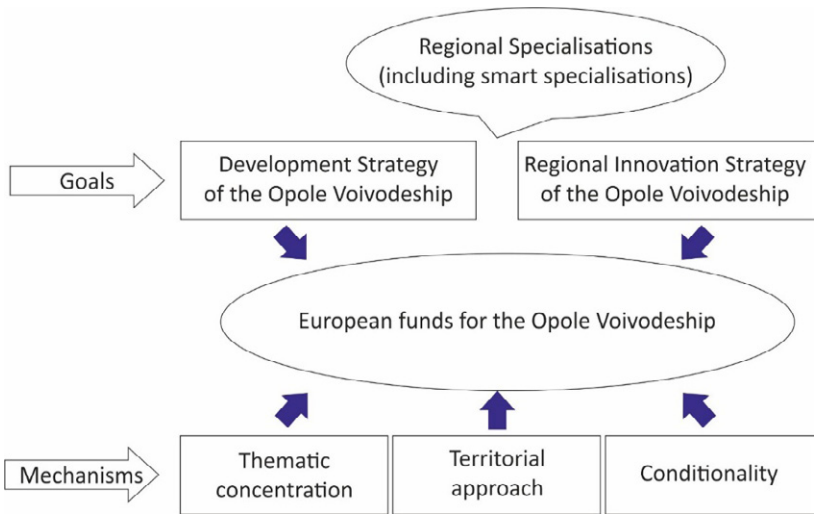

Figure 1. The essence of implementing smart specialisation in development policy – Strategies and Programmes

Source: authors' work based on Malik (2013a, 2013b) and Malik and Bedrunka (2013).

DOI: 10.34659/eis.2025.93.2.979

The general conclusions regarding the understanding of innovation in development policy, based on the analysis of literature and strategic documents at the EU level, are summarised in Table 1. They indicate that support for innovation remains at the centre of modern development policy, and that the most important tool for this support is smart specialisations.

Based on literature studies and the demand expressed by territorial units, the research problem was formulated as the effective and efficient support for innovation in the broadly understood sphere of economic resilience through the use of smart specialisations in regional development policy. The fundamental essence of implementing smart specialisation into development policy is presented in Figure 1.

The original message behind implementing the procedure for identifying smart specialisations into regional innovation development strategies and (integrated) regional development strategies (Figure 1) was to focus public support on investments with the greatest innovation and competitiveness potential. It was assumed that this approach would contribute to faster economic growth, improved quality of life, and better environmental conditions (ensuring sustainable development). However, the changing regional environment and recent crises, in our opinion, necessitate updating this approach to include the criterion of integrated resilience. In connection with the above, the following research theses were formulated:

- The procedure for identifying regional specialisations used in the Opolskie Voivodeship is, in principle, appropriate for enhancing the resilience of the economy. It includes regional knowledge transfer, which plays a crucial role in reducing dependence on global supply chains – an essential factor given their susceptibility to disruption during global crises.
- The current procedure to identifying smart specialisations in regional innovation development policy should be supplemented with criteria that enhance the resilience of industries, technologies or products to external threats.
- Key criteria for strengthening the resilience of regional development capital include improving the public safety, mitigating disaster risks, and preventing developmental threats (hereinafter: SRP criteria).
- A well-adapted innovation development policy based on smart specialisations can serve as a crucial driver for enhancing economic resilience in EU regions.

The primary goal was to develop a method for identifying regional specialisations, operationally oriented to technological and product innovations, supporting the resilience of the region's economy. The application objective was to develop a pro-immunity modification of the existing procedure for identifying regional specialisations as an integral part of the innovation development strategy. The case study of the regional development policy was the Opole Voivodeship.

In the conditions of external threats, it is particularly important to identify factors supporting the resilience of industries, technologies, and products in the development (innovation) policy of the region. Such an approach should serve to build the resilience of regions – in line with the concept of *Regional Innovation Valleys* (one of the key elements of the new European Innovation Agenda in the area of advanced technologies), according to which it is important to combine regional potentials for value added of such cooperation (Commission Staff Working Document, 2022).

As concluded earlier, there is no generally accepted and recognised methodology for identifying smart specialisations. In the research, the author's method of double helix of cognition and knowledge transfer processes in the Opolskie Voivodeship was used to identify smart specialisations (for a description of the method see Malik et al., 2020).

The smart specialisation identification model in the Opolskie Voivodeship, according to the double helix method, is based on 3 stages related to the transfer of knowledge in the region:

1) Production: creation of innovative potential within the regional R&D sector.
2) Utilisation: transmission of R&D products to the regional economy.
3) Dissemination: creation of supra-regional advantages by market transactions.

Technology that occurs in all 3 phases of regional knowledge transfer is considered as smart specialisation (Table 2). A graphical representation of the model can be found in Figure 2.

DOI: 10.34659/eis.2025.93.2.979

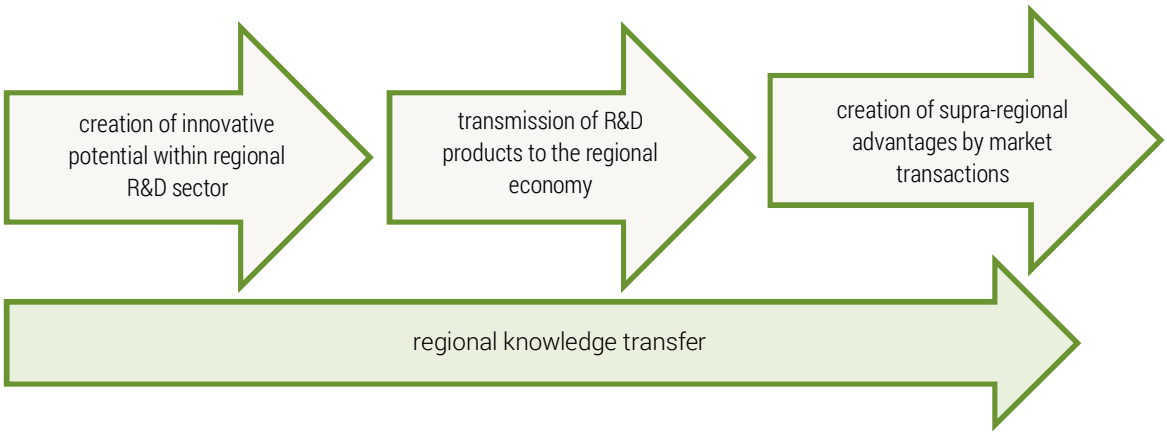

Figure 2. Graphical presentation of the smart specialisation identification model in the Opolskie Voivodeship
Source: authors' work based on Zarząd Województwa Opolskiego (2021).

Data to measure the region's innovative activity were collected as quantitative and qualitative from both primary sources (surveys, interviews) and secondary data sources (statistics, local government reports). The method of data collection was decoded by the phase of regional knowledge transfer, and so:

Stage 1: *Creation of innovative potential within regional R&D sector* was used by combining R+D works and expert opinions commissioned by enterprises, regional universities, scientific and research institutes; also information on improving qualifications by employees of enterprises was used;

Stage 2: *Transmission of R&D products to the economy*, information obtained from the Patent Office and information on the implementation of projects/investments to improve the competitiveness and innovation of enterprises in the region were used;

Stage 3: *Creation of supra-regional advantages by market transactions* was based on data from the rankings of the best companies in the region and the expert opinion of local government officials.

The data collected in this way were measured, zero unitarised, and then aggregated into a synthetic index. Then, classification was made – it was checked whether a given technology is present in the subsequent phases of knowledge transfer in the studied region. The results of the classification of the identified technologies are summarised in Table 2.

Table 2. Identification of technology groups according to a specific type od regional specialisation

	Technology groups	Creation of innovative potential within regional R&D sector	Transmission of products to the regional economy	Creation of supra-regional advantages by market transactions	Specialisations
1	Chemical technologies (sustainable)				performance regional specialisations
2	Sustainable construction and timber technologies				
3	Machinery and metal technologies				
4	Agri-food technologies				
5	Health processes, products and services and the quality of life				
6	ICT sector				potential smart specialisations
7	Intelligent mobility management systems				

DOI: 10.34659/eis.2025.93.2.979

	Technology groups	Creation of innovative potential within regional R&D sector	Transmission of products to the regional economy	Creation of supra-regional advantages by market transactions	Specialisations
8	Energy industry technologies including renewable energy sources				regional specialisations
9	Circular economy				
10	Knowledge-based education on new technologies and innovations				

Source: authors' work based on Zarząd Województwa Opolskiego (2021).

As shown in Table 2, 5 groups of technologies have been identified that are addressed at all stages of the regional knowledge sphere (smart specialisations), 2 groups of technologies that occur in two different phases of regional knowledge transfer (potential smart specialisations). 3 groups of technologies were identified only in one phase of knowledge transfer (specialisations of the R+D phase).

Results of the research

For the regional economy to withstand external shocks, it must be supported by resilient development capitals. Each form of capital has unique characteristics that contribute to different criteria of resilience. Their integration and mutual reinforcement foster more stable and resilient communities and economies. Therefore, resilience criteria have been taken into account for all critical elements of regional development capital.

In the process of applying the existing mechanism for identifying smart specialisations using the double helix method, specific resistance sub-criteria have been additionally taken into account:

1. improving the safety of residents (S),
2. mitigating the risk of disasters (R),
3. preventing developmental threats (P).

The indicated resilience sub-criteria are each time referred to the components of regional development capital, such as:

- public health (critical for the security and prevention of the social capital of the region's development),
- environmental resources, including energy resources (natural capital critical for the economy and people),
- quality of the life and environment, (critical natural capital for humans),
- cybersecurity and network security of business and administrative infrastructure (critical for economic and social capital),
- industrial production (critical economic capital),
- production and consumption of food and basic necessities (critical economic, social and human capital),
- buildings and structures (assets, which are critical for the security of people and the functioning of the economy and society).

The components of the region's development capital have been described in more detail in the literature (see, e.g., Malik, 2011). The identified components of regional development capital were analysed in terms of their importance for improving the region's resilience, each time using SRP sub-criteria of resilience (Table 3).

Table 3 presents an approach that takes into account the phases of knowledge transfer and the areas of strengthening the economic resilience of the region perceived as improvement of residents security (S), disasters risk minimisation (R) and developmental threats prevention (P), the so-called SRP criteria. In this way, critical areas for strengthening the resilience of the region's economy were identified. Then, all groups of regional specialisations previously identified in the process of knowledge transfer using the double helix method were analysed:

- smart specialisations,
- potential smart specialisations,

DOI: 10.34659/eis.2025.93.2.979

- regional R+D specialisations.

It is worth emphasising that the mechanism for identifying smart specialisations, like the entire innovation development strategy, is process-based. This means in practice that specialisations change, become potential smart specialisations, and these potential smart specialisations may be considered smart specialisations in the future. So the process should be monitored and updated constantly.

Table 3. Matrix for identifying regional specialisations oriented to support economic resilience

Phases of the knowledge transfer process Areas for strengthening the region's economic resilience	Production Creation of innovative potential within regional R&D sector	Utilization Transmission of products to the regional economy	Dissemination Creation of supra-regional advantages by market transactions	Regional Specialisations
Improving security, risk minimization and prevention in the field:	Definition criteria (conjunction according to knowledge transfer phases)			
1) public health (food security, microbiological, toxicological)	√	√	√	Logical conjunction by area of the public health
2) environmental management (water resources, raw materials, territory, atmospheric air)	√	√	√	Logical conjunction by area of the environmental management
3) cyber and network security	√	√	√	Logical conjunction by area of the cyber and network security
4) industrial security	√	√	√	Logical conjunction by area of the industrial security
5) structural security of buildings and structures	√	√	√	Logical conjunction by area of the structural security of buildings and structures
6) inancial security	√	√	√	Logical conjunction by area of the financial security
Cartesian product rankings of RSI priorities	Regional Specialisation areas ranked by the production phase	Regional Specialisation areas ranked by the use phase	Regional Specialisation areas ranked by the dissemination phase	Logical sum of Regional Specialisations = Smart specialisations integrated with the resilience of the economy

Discussion/Limitation and future research

The identification and updating of smart specialisations are focused on determining the unique features and assets of the region, highlighting competitive advantages, and aligning regional partners and resources around a vision for a future aimed at achieving a competitive and innovative economy (Zarząd Województwa Opolskiego, 2021). The essence of the original double-helix method used in the development of the Regional Innovation Strategy for the Opole Voivodeship 2020 is the application of the Cartesian product of technology groups simultaneously present in the regional knowledge transfer process and in the cognitive process – in regional documents and research conducted in this field (Malik, 2013b; Malik & Bedrunka, 2013).

In the process of supporting innovative projects for resilience development, it is crucial to finance measures and projects with public funds according to their affiliation with a specific group of specialisations in the regional economy. Priority will be given to resilience-enhancing projects within smart specialisations, followed by potential smart specialisations projects, and finally, initiatives within specialisations identified in only one phase of the knowledge transfer process.

DOI: 10.34659/eis.2025.93.2.979

Using this approach, an extensive analysis was conducted on example areas for strengthening the region's economic resilience from the perspective of the analysed regional specialisations. Each specialisation was assessed against the SRP resilience criteria across all phases of knowledge (technology) transfer. Table 4 contains an example element classified under the category of smart specialisation concerning plant production technology, evaluated in terms of the region's economic resilience areas according to SRP criteria and phases of technology transfer.

Table 4. Matrix for identifying regional specialisations oriented to support economic resilience – case for public health

Phases of the knowledge transfer process Areas for strengthening the region's economic resilience	Production Creation of innovative potential within regional R&D sector	Utilization Transmission of products to the regional economy	Dissemination Creation of supra-regional advantages by market transactions	Regional Specialisations
Improving security, risk minimization and prevention in the field:	Definition criteria (conjunction according to knowledge transfer phases)			
1) public health (food security, microbiological, toxicological)	1. safe technologies of plant production	1. safe technologies of plant production	1. safe technologies of plant production	1. safe technologies of plant production
Cartesian product rankings of RSI priorities	Regional Specialisation areas ranked by the production phase	Regional Specialisation areas ranked by the use phase	Regional Specialisation areas ranked by the dissemination phase	Logical sum of Regional Specialisations = Smart specialisations integrated with the resilience of the economy

An analogous analysis is conducted for all identified regional specialisations. As a result of the analytical and strategic work carried out, we obtain a list of technology groups characterised by the endogenous innovative potential of the region, focused around the identified areas for strengthening the region's economic resilience.

Conclusions

The model of modified innovation development policy based on smart specialisations presented in this work can be a significant factor in supporting innovation development for regional economic resilience.

In general, the procedure for identifying regional specialisations used in the Opole Voivodeship is appropriate from the perspective of enhancing economic resilience, as it emphasises regional knowledge (technology) transfer. The endogenous development of regions, in line with the concept of *Regional Innovation Valleys*, fosters the integration of regional potentials and creates added value from such cooperation.

In the identification policy procedure for smart specialisations, technological, product, and organisational innovations present in the regional knowledge transfer process should additionally be evaluated according to resilient sub-criteria for improvement of residents security, disasters risk minimisation and developmental threats prevention in the following areas:

- public health (including food, microbiological, and toxicological safety),
- resource and environmental quality management (including water, raw materials, energy resources, and air quality),
- cybersecurity and network security,
- production and consumption safety,
- safety of building and construction structures (including fire and flood infrastructure),
- financial security.

DOI: 10.34659/eis.2025.93.2.979

Thus, within the identified regional smart specialisations, a subset of innovative processes and products can be specified, whose support will additionally enhance the resilience of the regional economy under study.

This situation can be described as a double dividend. On one hand, it benefits regional society, the economy, and the environment by supporting innovative measures and projects. On the other, it strengthens resilience in the broadest sense, ensuring the sustainability and development of the region over both the short and long run.

The contribution of the authors

Conceptualisation, K.M. and M.S.S.; literature review, P.B. and M.S.S.; methodology, K.M. and M.S.S.; formal analysis, K.M., P.B. and M.S.S.; writing, K.M. and M.S.S.; conclusions and discussion, K.M., M.S.S. and P.B.

The authors have read and agreed to the published version of the manuscript.

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INTELIGENTNE SPECJALIZOWANIE JAKO KLUCZOWY CZYNNIK ODPORNOŚCI REGIONALNEJ GOSPODARKI

STRESZCZENIE: Celem badań jest opracowanie właściwego modelu polityki identyfikacji regionalnych inteligentnych specjalizacji w warunkach współczesnych zagrożeń zewnętrznych oraz związanej z nimi potrzeby wzmacniania odporności gospodarki regionalnej. Nowa metodyka identyfikacji i wspierania zrównoważonych inteligentnych specjalizacji stanowi istotny czynnik wspierania odporności gospodarki regionalnej. W badaniach wykorzystano metody analizy logicznej, strategicznej i statystycznej. Głównym wynikiem badań jest autorski model identyfikacji inteligentnych specjalizacji, uzupełniony o kryteria odporności dla rozwoju regionalnego. Zaproponowana procedura odpowiada na współczesne zagrożenia zewnętrzne, w tym konflikty zbrojne, przyspieszające zmiany klimatyczne, masowe migracje, pandemie i inne wyzwania. Oryginalność badań polega na opracowaniu ram polityki identyfikacji inteligentnych specjalizacji, które sprzyjają zarówno odporności zintegrowanej (w krótkim okresie), jak i zrównoważonemu rozwojowi (w długim okresie). Ramy te wypełniają lukę w dotychczasowych modelach kształtowania polityki odporności regionalnej, ze szczególnym uwzględnieniem wzmocnienia odporności gospodarczej regionów na współczesne zagrożenia zewnętrzne.

SŁOWA KLUCZOWE: polityka rozwoju, model identyfikacji inteligentnych specjalizacji, odporność gospodarki regionalnej, rozwój zrównoważony regionu, współczesne zagrożenia zewnętrzne

DOI: 10.34659/eis.2025.93.2.979