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FINAL REPORT //

Territorial Exaptive Resilience along EU Eastern Borders

TERRA RES

Final Report // December 2024

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The final version of the report will be published as soon as approved.

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Executive summary

This study provides a comprehensive analysis of territorial exaptive resilience along the EU's eastern borders, examining how regions mobilize and repurpose existing assets and capabilities in response to external challenges or shocks. Through rigorous quantitative analysis and detailed case studies, the research advances our understanding of regional adaptation and transformation in peripheral areas, contributing to both theoretical discourse and policy development.

The analysis of structural conditions across European regions reveals significant territorial disparities. Employing Latent Class Analysis, the study identifies six distinct regional types, with **eastern border regions predominantly classified as "Industrial-Agricultural Peripheries**." These regions exhibit the lowest levels of employment and gross value added at European level, alongside weak local resilience indicators and limited institutional capacity. Despite receiving substantial EU funding support, they remain characterized by structural weaknesses and constrained resource endowments, reflecting persistent core-periphery dynamics within the European space.

However, the examination of regional responses to successive crises through the Territorial Exaptive Resilience Index (TERI) presents a more nuanced understanding of these regions' coping capacities**. While central European regions predominantly demonstrate resistance-based resilience, maintaining stability through economic perturbations, eastern border regions exhibit notable capacity for exaptive resilience - the ability to transform and adapt through creative resource reallocation**. This pattern manifests consistently across multiple crisis periods, from the 2008 financial crisis through the COVID-19 pandemic and recent geopolitical tensions.

The econometric analysis identifies several critical determinants of exaptive resilience. **Institutional quality** emerges as a fundamental driver, alongside **knowledge infrastructure** and **local resilience**. Notably, **traditional sectors**, often perceived as impediments to development, **can function as assets** when effectively repurposed within new development trajectories. The analysis further demonstrates that **EU funding has a particularly positive impact in border regions**, suggesting that its effectiveness is amplified when aligned with cross-border dynamics. This highlights the importance of fostering institutional and social innovation to maximize the benefits of policy interventions in these contexts.

These quantitative findings are substantiated and enriched through detailed case studies of five strategically selected border regions. The qualitative component of this study reveals the nuanced ways in which territorial exaptive resilience manifests across the border regions. Each case study highlights a unique interplay of local resources, institutional frameworks, and socio-economic strategies in responding to crises. Maramureș County showcases the **transformative potential of converting environmental challenges into sustainable opportunities,** as evidenced by the SPIRE project, which mobilized local actors to repurpose industrial liabilities for renewable energy and ecological restoration. In Lapland, the combination of traditional knowledge and innovation has fostered diversification into Arctic testing, bioeconomy and tourim sectors**, turning geographic isolation into a competitive advantage**. Szabolcs-Szatmár-Bereg County demonstrates the **critical role of social capital in resilience-building**, leveraging grassroots networks to respond effectively to the Ukrainian refugee crisis while strengthening regional cohesion. The Olsztyn Region highlights the challenges of **adapting to disrupted cross-border dynamics**, with its agricultural sector poised for transformation through inclusive rural development strategies. Meanwhile, Vilnius County exemplifies the importance of **institutional coordination in navigating geopolitical and security challenges**, demonstrating how governance frameworks can enhance adaptability under pressure.

The synthesis of these findings underscores three key drivers of resilience: **the mobilization of local networks and resources**, the alignment of **institutional frameworks** with place-based needs, and **strategic investments in skills and infrastructure**. Together, these elements offer a coherent framework for fostering exaptive resilience in border regions. The case studies reveal that resilience is not a static trait but a dynamic process shaped by the capacity to creatively repurpose existing resources and adapt to external pressures. The comparative analysis not only highlights the diversity of responses across regions but also identifies shared lessons for empowering communities, fostering innovation, and navigating the complexities of cross-border governance.

The research findings necessitate a reconsideration of EU cohesion policy post-2027. They advocate for **a more nuanced, place-based approach that recognizes and enhances** the exaptive capacities of border regions. This entails developing **flexible funding mechanisms** responsive to emerging opportunities, **strengthening cross-border governance frameworks**, and **investing in both physical infrastructure and social capital development**. The evidence suggests that successful regional development requires balancing structural stability with adaptive capacity, fostering innovation while maintaining valuable traditional sectors, and supporting both formal institutions and informal networks.

The study concludes that building resilient border regions requires moving beyond traditional development paradigms toward more transformative approaches that empower local communities and foster cross-border cooperation. As Europe confronts increasing uncertainty from climate change, geopolitical tensions, and technological disruption, the experience of eastern border regions offers valuable insights into processes of regional adaptation and transformation. Their trajectory suggests that sustainable development emerges not from resistance to change, but through the capacity to creatively repurpose existing resources for new development pathways, ultimately enhancing both regional and EU-wide competitiveness.

This research provides a comprehensive framework for understanding and enhancing territorial exaptive resilience in border regions, offering empirically-grounded guidance for policymakers and stakeholders engaged in regional development. The findings indicate that with appropriate support and policy frameworks , eastern border regions can transform their peripheral position into a source of innovative adaptation, enhancing both regional competitiveness and contributing to more balanced and sustainable development across the European Union.

1 Introduction

1.1 Background and context

In an increasingly interconnected and turbulent world, regions face a myriad of complex challenges that test their ability to adapt, transform, and thrive. From economic crises, social and technological disruptions to geopolitical tensions and climate change, these challenges have far-reaching and uneven impacts on local economies and communities (Christopherson et al., 2010; Pike et al., 2010). The COVID-19 pandemic has further exposed the vulnerability of regions to global shocks, highlighting the urgent need for building resilience (Bailey et al., 2020; Gong et al., 2020).

Border regions, in particular, find themselves at the forefront of these challenges. Often characterized by peripheral locations, lower levels of development, and limited access to resources (Trippl et al., 2020; Medeiros, 2019), border regions are more susceptible to the disruptive effects of external shocks, such as shifts in trade regimes or migration flows (Durand & Decoville, 2020). Yet, their unique position at the intersection of different national systems and cultures also presents opportunities for developing cross-border synergies, accessing complementary assets, and fostering innovation (Sohn, 2014; Makkonen et al., 2018).

Against this backdrop, the concept of resilience has emerged as a powerful framework for understanding and enhancing the capacity of regions to withstand, adapt to, and recover from adversity (Christopherson et al., 2010; Foster, 2007). Departing from traditional equilibrium-based notions, evolutionary perspectives emphasize the dynamic and transformative dimensions of resilience (Boschma, 2015; Martin & Sunley, 2015). Resilience, in this view, is not merely about bouncing back to a pre-existing state, but also about "bouncing forward" by reconfiguring structures and creating new growth paths (Bristow & Healy, 2014; Davoudi et al., 2012).

This study advances this perspective by introducing the concept of territorial exaptive resilience. Drawing on the evolutionary notion of exaptation (Gould & Vrba, 1982), exaptive resilience refers to the capacity of regions to repurpose and redeploy existing assets and capabilities for new functions and applications in the face of change (Kollár & Kollár, 2020). It captures the creative potential of regions to diversify their economies, find novel solutions, and carve out new development opportunities (Valdaliso et al., 2021; Balland et al., 2019).

The EU's eastern border regions offer a compelling context for exploring exaptive resilience. Spanning external borders with non-EU countries and internal borders between member states, these regions have been grappling with a range of persistent and emerging challenges, from economic underdevelopment and demographic decline (Győrffy 2022, Endrődi-Kovács & Tankovsky 2023 ,Eurostat 2024, Decoville & Durand, 2019)) to the disproportionate impacts of recent crises like the COVID-19 pandemic, the war in Ukraine, and the refugee crisis (Capello et al 2023, IOM 2024)). At the same time, these regions possess unique assets and potentials, such as strategic locations, rich cultural heritage, and opportunities for cross-border cooperation (Medeiros, 2019; Dołzbłasz, 2021), which could be harnessed for exaptive resilience and development.

Enhancing the exaptive resilience of eastern border regions is not only crucial for their own sustainable development but also aligns with the broader goals and priorities of EU cohesion policy. The current policy framework (2021-2027) places a strong emphasis on resilience, innovation, and sustainability, introducing new instruments like the "Interregional Innovation Investments" to support the scaling up of innovative solutions across borders (European Commission, 2021). Moreover, in response to recent crises, the EU has launched targeted initiatives, such as REACT-EU and the Eastern Partnership policy, to support the recovery and resilience of border regions (European Commission, 2020).

However, there remains a lack of systematic and comparative research on the specific challenges, opportunities, and strategies for building exaptive resilience in the EU's eastern border regions. This study aims to fill this gap by developing a novel conceptual framework and mixed-methods approach to analyze territorial exaptive resilience in a comparative perspective. By generating new empirical insights and policy recommendations, the study seeks to inform the design and implementation of cohesion policy interventions to effectively support the long-term resilience and development of these regions.

The findings of this study can contribute to the broader academic and policy debate on regional resilience, evolutionary approaches to regional development, and the future of cohesion policy. They can help identify the specific needs, potentials, and barriers of different border regions, and guide the development of more targeted and place-based policy measures. Ultimately, by shedding light on the mechanisms and conditions for exaptive resilience, this study can support the efforts to promote a more resilient, innovative, and sustainable Europe.

1.2 Research objectives and questions

The main aim of this study is to provide a comprehensive and policy-relevant understanding of territorial exaptive resilience in the EU's eastern border regions. To achieve this, the research pursues several interconnected objectives and questions that address the conceptual, methodological, empirical, and policy dimensions of the topic, with a specific focus on the following key questions:

- How can exaptive resilience be translated to the situation of the eastern EU external border? Is it possible to find a new development path for territory/region as opposed to path dependency?
- How to develop and harness the exaptive capacity of regions along external EU borders?
- How to measure the exaptive resilience of these regions? Which factors/drivers contribute to it?
- Which are the new paths for capitalizing and reutilizing the local resources (local competitive advantages) to enhance resilience in the long term?
- How can existing governance structures be adapted or reconfigured to facilitate exaptive resilience in regions along the eastern EU external borders? What multi-level policy mechanisms can promote resilience? Are new standards for coordination needed, in order to help ensure more consistency, clarity, and coherence between top-down decision-making and bottom-up stakeholder actions?
- How can the new cohesion policy and other mechanisms (after 2027) more efficiently support border regions and ensure their development in the face of ever more rapidly changing socio-economic conditions and challenges? Do these need new/special tools (e.g., areas of specific intervention, special strategies)? What kind of support would be most effective (financial, legal changes)?

To address these key research questions and achieve the study's objectives, the research adopts a multi-dimensional approach that integrates conceptual, methodological, empirical, and policy perspectives.

Conceptually, the study seeks to develop a clear and operational definition of territorial exaptive resilience that is grounded in the specific context of the EU's eastern border regions. It critically engages with the existing literature on regional resilience, evolutionary economic geography, and border studies to identify the key features, mechanisms, and indicators of exaptive resilience in cross-border settings. This conceptual framework serves as the foundation for the subsequent methodological and empirical analyses.

Building on this conceptual framework, the study develops a novel methodological approach to measuring the exaptive resilience of regions across the EU. This involves the construction of the Territorial Exaptive Resilience Index (TERI), which incorporates both resistance and reallocation capacities, considering multiple time periods and economic contexts to capture the dynamic and evolutionary nature of regional resilience. The TERI provides a robust and policy-relevant tool for assessing and comparing the resilience of border regions across the EU.

Empirically, the study employs a comprehensive, mixed-methods approach to examine the driving forces and patterns of exaptive resilience in the EU's regions. It combines spatial, temporal, and econometric analyses to investigate the spatial patterns of exaptive resilience profiles, their evolution over time, and the economic, institutional, and social factors that predict resilience outcomes. These quantitative analyses are complemented by in-depth case studies of selected border regions, which provide a more nuanced and contextualized understanding of the drivers, barriers, and best practices for building exaptive resilience. The integration of quantitative and qualitative methods allows for a rich and multi-faceted analysis of territorial exaptive resilience.

Drawing on the conceptual, methodological, and empirical insights, the study derives concrete policy implications and recommendations for strengthening the exaptive resilience of the EU's eastern border regions, in line with the goals and priorities of EU cohesion policy. It translates the research findings into actionable proposals for policymakers at different levels and contributes to the ongoing debate on the future of cohesion policy. By providing a novel and policy-relevant framework for understanding and promoting the adaptation and transformation of border regions, the study aims to inform the design and implementation of more effective and place-based cohesion policy interventions.

By addressing these multi-faceted research questions and objectives through an integrated approach, the study aims to make a significant contribution to the academic and policy debate on territorial resilience and cross-border cooperation in the EU. It provides new insights and recommendations for supporting the long-term resilience and sustainable development of the strategically important but understudied eastern border regions, contributing to the broader goal of promoting a more resilient, inclusive, solidarity-based and prosperous Europe.

2 Theoretical Framework

2.1 Defining Exaptive Resilience

Building on the broader resilience framework, the concept of exaptive resilience focuses on a specific mechanism through which systems can transform in the face of disruptive change. Exaptation, a term borrowed from evolutionary biology, refers to the repurposing of an existing trait or structure for a new function, different from the one it was originally selected for (Gould & Vrba, 1982). In the field of resilience studies, Kollár and Kollár (2020) define exaptive resilience as a complex system's capacity to respond to external shocks or changes by repurposing its existing traits or characteristics for new objectives or functions, enabling the system to develop and thrive under altered conditions. This stands in contrast to adaptive resilience, which is focused on maintaining predefined functions and solving well-defined problems within a given framework. Exaptive resilience, on the other hand, emerges in response to unexpected, unpredictable crises, repurposing existing assets and capabilities for new uses that were not originally envisioned (Miskolczi et al 2024, Miskolczi – Kollár 2024).

The exaptive resilience framework offers a novel perspective on how systems can not only bounce back from disruptions but also bounce forward by using crises as opportunities for innovation and renewal. It shifts the focus from the preservation of existing structures to the creative recombination of assets and capabilities to generate new development paths. This aligns with the growing recognition in resilience studies that resilience is not just about stability and recovery, but also about transformation and regeneration (Davoudi et al., 2012). Moreover, the exaptive resilience framework is well-suited to capture the complex, non-linear dynamics of economic systems in the face of deep uncertainty, making it a valuable tool for understanding and fostering resilience in a world of accelerating change and mounting unpredictability.

2.2 Defining Territorial Exaptive Resilience

DEFINITON OF TERRITORIAL EXAPTIVE RESILIENCE

Territorial exaptive resilience is a region's ability to repurpose its existing resources and capabilities, which were originally developed for different functions, to create new growth opportunities and evolve in response to changes or crises

Building on the concept of exaptive resilience, territorial exaptive resilience focuses on the specific manifestations and drivers of exaptive resilience at the regional scale, with a particular emphasis on the role of geographic context and spatial relationships. We define territorial exaptive resilience as a region's ability to repurpose its existing resources and capabilities, which were originally developed for different functions, to create new growth opportunities and evolve in response to changes or crises.

At its core, territorial exaptive resilience is about leveraging a region's existing assets in new and creative ways. It involves identifying the latent potential of a region's resources and finding novel applications for them that can drive new growth opportunites (Gould & Vrba, 1982; Andriani & Cohen, 2013). This emphasis on repurposing and recombining existing resources and capabilities, rather than simply acquiring new ones, is what sets exaptive resilience apart from other forms of regional resilience, such as adaptive resilience, which focus more on incremental adjustments and the accumulation of new resources (Boschma, 2015; Martin & Sunley, 2015).

Moreover, territorial exaptive resilience is not just about bouncing back from crises and disruptions, but also about bouncing forward by seizing the new growth opportunities that often emerge from such challenges (Boschma, 2015; Martin & Sunley, 2015). It requires a proactive and future-oriented mindset that looks beyond mere survival or recovery and actively seeks to shape a region's development trajectory. However, the ability of regions to engage in exaptive resilience is deeply shaped by their specific historical, institutional, and geographic conditions (Boschma, 2015; Grillitsch &

Sotarauta, 2020). Exaptive resilience involves a degree of breaking free from path dependencies, finding new development opportunities that build on, but are not constrained by, a region's past. This path-breaking potential is often triggered or accelerated by major disruptions and crises, which can act as catalysts for regional transformation by creating new needs and opportunities that regions can seize through exaptive strategies (Boschma, 2015; Martin & Sunley, 2015).

The concept of territorial exaptive resilience are particularly relevant for border regions, especially in the eastern periphery of the EU. These regions often face unique challenges due to their geographic location, such as limited accessibility, economic marginalization, and institutional fragmentation (Medeiros, 2019; Dołzbłasz, 2020). They also tend to have a higher exposure to external shocks and disruptions, such as geopolitical tensions, trade fluctuations, and migration flows (Durand & Decoville, 2020). Moreover, border regions often possess distinctive assets and capabilities that have been shaped by their history of cross-border interactions and exchanges, such as cultural diversity, multilingualism, and transnational networks (Sohn, 2014; Makkonen et al., 2018).

In this context, the notion of exaptive resilience offers a promising framework for understanding and promoting the transformation of border regions in the face of major challenges. By emphasizing the creative repurposing and recombination of existing assets, exaptive resilience highlights the potential of border regions to leverage their unique resources and capabilities for new growth opportunities.

2.3 Territorial Exaptive Resilience and Exaptibility

TERRITORIAL EXAPTIVE RESILIENCE INDEX

Exaptive resilience describes a region's reactive ability to repurpose assets during crises, while adaptability and exaptibility capture the structural and systemic capacities needed for long-term transformation

In exploring the concept of territorial exaptive resilience, which captures a region's capacity to repurpose and recombine its existing assets to create new growth opportunities amidst transformative changes or crises, it is equally fertile to introduce and elaborate the concept of exaptibility. Exaptibility refers to a region's underlying capacity to cultivate and maintain the conditions that enable such exaptive processes to occur. Exaptibility can be understood as a region's potential for exaptive resilience. It is about the systemic and structural factors that enable a region to continuously identify, valorize, and mobilize its latent resources and capabilities for new purposes and in new contexts (Grillitsch & Sotarauta, 2020).

To fully understand the role of exaptibility, it is essential to distinguish it from related concepts such as adaptability, adaptive resilience, and exaptive resilience. These concepts can be situated within a framework that considers two key dimensions of regional, provincial and local response to change: the degree of change (incremental vs. transformative) and the orientation of change (reactive vs. proactive). This framework clarifies their interconnections and contributions to regional development strategies, highlighting the balance between preparation and response.

Table 2.1
Adaptibility, exaptibility, adaptive resilience and exaptive resilience

Dimension	Incremental Change	Transformative Change
Proactive (Preparation)	Adaptability: Gradual improvements within existing systems.	Exaptibility: Cultivation of capacities and conditions for future transformation.

Dimension	Incremental Change	Transformative Change
Reactive (Response)	Adaptive Resilience: Absorption and recovery from shocks.	Exaptive Resilience: Creative repurposing of existing assets during crises.

Adaptability refers to a region's capacity for incremental, proactive adjustments within its existing development trajectory. It is characterized by gradual improvements in systems, skills, or infrastructure to better align with evolving challenges or opportunities without fundamentally altering the core structure (Boschma, 2015; Martin & Sunley, 2015). Proactive by nature, adaptability ensures that regions are equipped to handle foreseeable changes through enhancements to existing capabilities and frameworks. In contrast, adaptive resilience focuses on a region's reactive ability to absorb and recover from shocks while preserving its essential identity and trajectory. It prioritizes restoring equilibrium and mitigating immediate disruptions rather than pursuing long-term transformation (Bristow & Healy, 2014; Hu & Hassink, 2017). Adaptive resilience emphasizes stability, enabling regions to "bounce back" after crises with minimal structural alteration.

Exaptive resilience captures a region's reactive capacity that creates the potential for repurposing and recombining existing assets for transformative change in response to major disruptions. It reflects the creative potential of crises, enabling regions to "bounce forward" by leveraging existing resources in novel ways to seize emergent opportunities (Gould & Vrba, 1982; Boschma, 2015). While adaptive resilience aims to restore, exaptive resilience embraces transformation, highlighting the innovative use of resources and capabilities. Exaptibility, by contrast, represents a region's proactive capacity to cultivate the conditions necessary for future exaptive processes. This involves building preconditions—such as flexible institutions, diversified skill bases, and multifunctional infrastructure—that enable transformative change when disruptions arise. Exaptibility ensures that regions are not only prepared for known challenges but also equipped to navigate and capitalize on unpredictable opportunities.

In conclusion, the concept of exaptibility represents a crucial extension and complement to the notion of territorial exaptive resilience. This relationship is fundamental to understanding regional development and competitiveness: while resilience represents the potential for transformation, it is the dynamic interplay between adaptability and exaptibility that determines whether and how this potential materializes into actual structural change - adaptability through gradual improvements within existing systems, and exaptibility through the cultivation of capacities for future transformation. While exaptive resilience focuses on the reactive potential for repurposing and recombining regional assets in response to specific crises and disruptions, exaptibility is about the underlying capacity to engage in such processes over the long term. It reflects the proactive and future-oriented cultivation of a region's institutional, social, and cognitive infrastructures, enabling ongoing transformation and enhanced regional competitiveness through innovation and adaptation...

2.4 Relevance to EU Cohesion Policy and Border Regions

The concepts of territorial exaptive resilience and exaptibility have significant implications for EU cohesion policy and its focus on border regions. Cohesion policy aims to reduce regional disparities, strengthen economic, social, and territorial cohesion, and promote sustainable and inclusive growth (European Commission, 2021). Border regions are a key target and beneficiary of cohesion policy, as they often face specific challenges and opportunities that require tailored and integrated interventions (European Commission, 2022).The concept of territorial exaptive resilience aligns well with the place-based and integrated approach of cohesion policy (Berkowitz et al., 2017; Wróblewski et al., 2022). By focusing on the endogenous potential and creativity of border regions to adapt and transform their economies through cross-border cooperation and integration, exaptive resilience can help identify the specific assets, challenges, and opportunities of each border region, and design more targeted and effective interventions that build on the region's strengths and address its weaknesses (Dołzbłasz, 2020). Moreover, the multi-dimensional and multi-level nature of exaptive resilience

resonates with the holistic and partnership-based approach of cohesion policy, which emphasizes the importance of involving and empowering regional, provincial and local stakeholders in the design, implementation, and monitoring of interventions (European Commission, 2021; Wróblewski et al., 2022).

The notion of exaptibility, in particular, can provide valuable insights for cohesion policy in fostering the long-term transformative capacity and competitiveness of border regions. By emphasizing the proactive and future-oriented cultivation of a region's institutional, social, and cognitive infrastructures, exaptibility highlights the importance of investing in the enabling conditions and capacities that allow border regions to continuously identify and seize new growth opportunities over time (Boschma, 2015). This perspective can inform the design and implementation of cohesion policy interventions that not only address the immediate needs and challenges of border regions but also build their resilience to future shocks and opportunities. Furthermore, the concepts of exaptive resilience and exaptibility can contribute to the ongoing debate on the future of cohesion policy and its role in supporting the recovery and resilience of regions in the face of global challenges, such as the COVID-19 pandemic, climate change, or digital transformation (European Commission, 2021; 2022). These concepts offer a forward-looking and transformative perspective on how border regions can not only recover from crises but also build back better and greener by leveraging their untapped assets and synergies for smart and sustainable development (Baumgartinger-Seiringer et al., 2021; Eder & Trippl, 2019).

In conclusion, the concepts of territorial exaptive resilience (and exaptibility) have significant relevance and applicability to EU cohesion policy and its focus on border regions. They provide a novel and useful framework for guiding and assessing the interventions of cohesion policy in border regions, by emphasizing the endogenous potential and creativity of these regions to adapt and transform their economies through cross-border cooperation and integration. These concepts highlight how regions can enhance their competitiveness by creatively repurposing existing assets and capabilities, contributing to the EU's overall competitive position. Moreover, they contribute to the ongoing debate on the future of cohesion policy and its role in supporting the recovery and resilience of regions in the face of global challenges. By operationalizing and applying these concepts to the case of the EU's eastern border regions, this study aims to generate valuable insights and recommendations for enhancing the effectiveness and impact of cohesion policy in these regions, and for promoting their sustainable and inclusive development in the post-2027 period.

3 Methodology

3.1 Quantitative Analysis

3.1.1 Territorial Exaptive Resilience Index (TERI)

TERRITORIAL EXAPTIVE RESILIENCE INDEX

Resistant Regions: High on resistance but low on reallocation, these regions withstand shocks by preserving their economic structure without significant sectoral shifts.

Exaptive Resilient Regions: High on both resistance and reallocation, these regions maintain their economic stability while reallocating their economic structure.

Non-Resilient Regions: Low on resistance, these regions struggle to maintain prosperity during shocks, lacking the capacity to withstand or adapt effectively.

The Territorial Exaptive Resilience Index (TERI) is a novel composite index that aims to capture the multifaceted nature of regional resilience and adaptability in the face of economic shocks. The TERI is calculated using employment and Gross Value Added (GVA) data at the NUTS3 level from Eurostat[1] datasets, ensuring comparability across EU border regions (Sensier et al., 2016)[2]. To capture territorial exaptive resilience, the TERI incorporates two key dimensions: reallocation and resistance. The Reallocation Index measures the extent to which a region can adapt its economic structure by reallocating labor and production across sectors, providing a nuanced measure of the magnitude and direction of sectoral reallocation within a region. The Resistance Index gauges a region's ability to withstand economic shocks, reflecting its short-term coping capacity and ability to avoid major economic losses and disruptions (Sensier et al., 2016; Martin & Sunley, 2015).

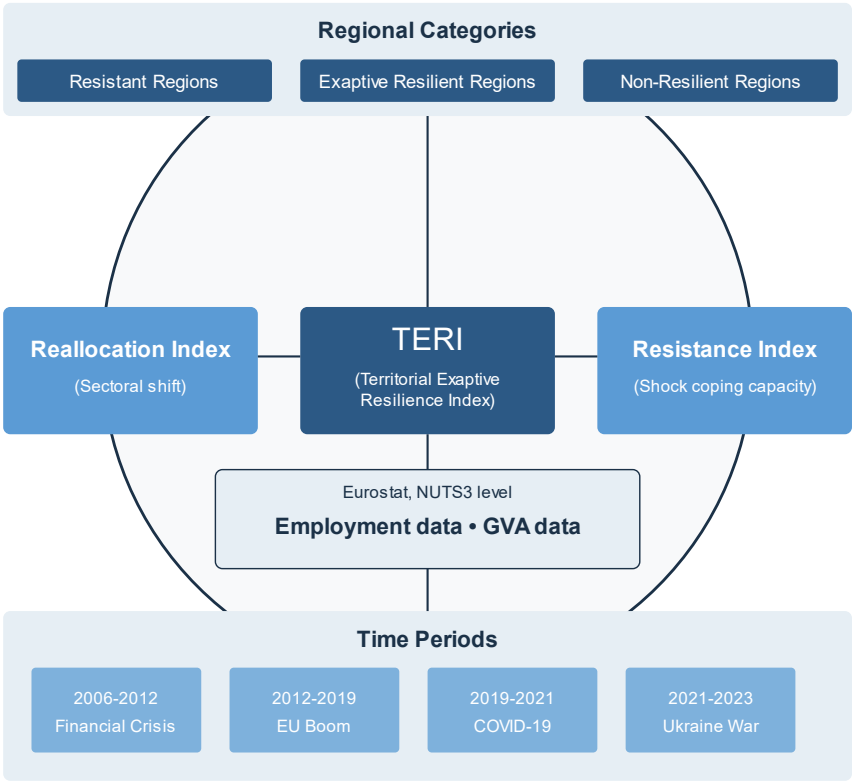
The TERI also incorporates a temporal dimension by assessing regional performance over four distinct time periods, each corresponding to a specific economic context: the 2008 financial crisis (2006-2012), the EU economic boom (2012-2019), the COVID-19 pandemic (2019-2021), and the ongoing war in Ukraine (2021-2023[3]). The underlying analytical logic focuses on comparing pre-crisis and post-crisis periods to capture how regions reallocate resources and adapt their economic structures in response to major disruptions.

[1] For regions with missing data (particularly Switzerland), we supplemented our analysis with data from the Joint Research Centre's ARDECO database (https://urban.jrc.ec.europa.eu/ardeco/explorer).

[2] .Due to data limitations, NUTS2 employment data is used for this period.

[3] Two methodological considerations apply to this period. First, since the conflict is ongoing, the 2023 data represent an active crisis scenario rather than a clear post-crisis phase. Second, although ARDECO estimates were available, we chose to use Eurostat data to ensure that sectoral changes are based on actual rather than interpolated figures, thereby requiring the use of NUTS2-level data.

Figure 3.1
Territorial Exaptive Resilience Index



This approach allows for a dynamic and contextual understanding of resilience and adaptability (Sensier et al., 2016). The construction of the TERI involves carefully considered methodological choices, such as the use of the geometric mean for aggregation, which ensures a balanced representation of the sub-indices (OECD, 2008). Regions are then categorized into three distinct groups based on their relative performance: Resistant Regions, Exaptive Resilient Regions, and Non-Resilient Regions. This categorization enhances the interpretability of the TERI and allows for a more nuanced understanding of regional resilience patterns.

3.1.2 Factors Influencing Exaptive Resilience: Hypotheses and Econometric Model

To investigate the factors influencing exaptive resilience, we draw on the literature on regional economic resilience and adaptability (Martin & Sunley, 2015; Boschma, 2015; Hassink, 2010) and identify five key dimensions: local resilience factors, economic structure (related variety), innovation capacity (R&D intensity), institutional quality, and EU cohesion policy support. We develop hypotheses linking each dimension to exaptive resilience and propose a Bayesian multinomial panel regression model to test these relationships empirically.

1. Local Resilience: We argue that regions with higher levels of happiness, income, and intra- and inter-regional connections are more likely to be categorized as resistant or exaptive resilient. These factors are measured using the European Social Survey data (happiness), harmonized disposable income data (Mikou et al., 2024), and the Social Connectedness Index (Bailey et al., 2018). These variables serve as proxies for the social capital, interregional connectivity, and quality of life in a region, which have been recognized as important foundations for regional resilience (Magis, 2010; Wilson, 2012).
2. Related Variety: We hypothesize that regions with higher related variety in their economic structure are more likely to be categorized as resistant or exaptive resilient. Related variety is measured using an entropy-based measure that captures the diversity of industries within a region, based on a simplified categorization of NACE Rev. 2 sectors. This measure serves as a proxy for the presence of technologically related but distinct sectors in a region's economy, which is thought to facilitate knowledge spillovers, cross-sectoral learning, and the recombination of existing capabilities into new applications and markets (Frenken et al., 2007; Boschma & Frenken, 2011).
3. R&D Intensity: We argue that regions with higher R&D intensity are more likely to be categorized as resistant or exaptive resilient. R&D intensity is measured using the share of employment and gross value added (GVA) generated by the "Professional, scientific and technical activities; administrative and support service activities" sector (NACE Rev. 2 codes K – N) at the NUTS3 level Dallhammer et al. 2020. These variables serve as proxies for a region's investment in and capacity for innovation, which has been identified as a key factor in enabling regions to develop new technologies, products, and processes in response to changing market conditions (Crescenzi et al., 2016; Bristow & Healy, 2018).
4. Institutional Quality: We hypothesize that regions with higher institutional quality are more likely to be categorized as resistant or exaptive resilient. Institutional quality is measured using data from the European Quality of Government Index (EQI), which is based on surveys of citizens' perceptions and experiences with corruption, impartiality, and quality of public services (Charron et al., 2014, 2015, 2019, 2022, 2024). This index serves as a proxy for the quality of governance and public service in a region, which has been recognized as a critical determinant of regional economic resilience (Rodríguez-Pose & Ketterer, 2020; Eraydin, 2016, Miskolczi 2020).
5. EU Funds: We argue that border regions that received higher EU funds are more likely to be categorized as resistant or exaptive resilient. EU funds are measured using the "Historic EU payments - regionalized and modelled" dataset, which provides annual expenditure data for specific EU funds (ERDF, Cohesion Fund, EAFRD/EAGGF, and ESF) at the NUTS2 level. Since our analysis is conducted at the NUTS3 level, we disaggregate the NUTS2-level data by population shares within each NUTS3 region. This approach assumes that EU funds are distributed proportionally to population size within NUTS2 regions, which serves as a practical approximation when detailed data is not available (Crescenzi & Giua, 2020). This variable serves as a proxy for the financial resources provided by EU cohesion policy to border regions, which can enhance their capacity to invest in infrastructure, human capital, and innovation, and adapt and transform their economies and increase it's competitiveness (Scotti et al 2022).

The Bayesian multinomial panel regression model is particularly suitable for this analysis, as it allows for the quantification of uncertainty in parameter estimates, provides a principled way to incorporate prior knowledge, and can easily accommodate complex data structures (Gelman et al., 2013; McElreath, 2020). The model is estimated using Markov Chain Monte Carlo (MCMC) methods implemented in the brms package in R (Bürkner, 2017), which provides a flexible and user-friendly interface for specifying and fitting Bayesian regression models.

To account for potential panel effects in our data, we include both region-specific and year-specific random effects in our model specification. These random effects capture unobserved heterogeneity across regions and years, respectively, which may influence the relationship between our explanatory variables and the exaptive resilience categories. By including these random effects, we control for potential correlations within regions over time and within years across regions, ensuring that our estimates are not biased by these panel effects (Bell et al., 2019; Gelman & Hill, 2006).

The region-specific random effect captures time-invariant factors that may affect a region's resilience category but are not explicitly included in the model, such as geographic characteristics, historical legacies, or cultural factors. The year-specific random effect, on the other hand, accounts for temporal shocks or trends that affect all regions simultaneously, such as macroeconomic fluctuations, technological changes, or policy shifts at the EU level.

Table 3.1
Control Variables in the Bayesian Multinomial Panel Regression Model

Variable	Description
Population Density	Number of inhabitants per square kilometer in each NUTS 3 region
Urbanization Level	Categorical variable classifying NUTS 3 regions into predominantly urban, intermediate, or predominantly rural areas
Employment Ratio	Ratio of employed persons to the total population in each NUTS 3 region
Agriculture Employment Share	Percentage of a region's total employment in the agriculture, forestry, and fishing sector (NACE Rev. 2 section A)
Manufacturing Employment Share	Percentage of a region's total employment in the manufacturing sector (NACE Rev. 2 section C)
GVA per Capita	Gross value added per inhabitant, expressed in euros
Manufacturing GVA Share	Percentage of a region's GVA generated by the manufacturing sector (NACE Rev. 2 section C)
Agriculture GVA Share	Percentage of a region's GVA generated by the agriculture, forestry, and fishing sector (NACE Rev. 2 section A)
Eastern Border Country	Dummy variable taking the value of 1 if the NUTS 3 region belongs to a country on the eastern border of the EU, and 0 otherwise

The inclusion of these control variables in our econometric model ensures that we account for the potential confounding effects of demographic, economic, and business factors on regional exaptive resilience. By controlling for these factors, we can more accurately estimate the impact of our explanatory variables of interest, such as institutional quality, individual resilience, and cross-border cooperation.

3.1.3 Territorial Exaptive Resilience Capacity Classes (TERC)

To explore the underlying structure of the data and identify distinct Territorial Exaptive Resilience Capacity Classes (TERC) among EU regions, we employ latent class analysis (LCA), a statistical method that allows for the identification of unobserved subgroups within a population based on observed variables (Mclust, Scrucca et al., 2016). LCA is particularly suitable for this analysis, as it can simultaneously consider multiple observed variables, such as employment ratios, GVA per capita, population density, local resilience, knowledge instense sectors, and institutional factors, in determining the latent class membership of regions.

The LCA model is implemented using the mclust package in R (Scrucca et al., 2016), which uses a Gaussian mixture model-based approach to clustering. The optimal number of clusters is determined by selecting the model with the lowest Bayesian Information Criterion (BIC) (Schwarz, 1978). The resulting TERCs provide a typology of EU regions based on their economic, demographic, social and

institutional profiles, offering insights into the different types of regions present in the EU and their potential for exaptive resilience.

3.1.4 Missing Data and Imputation

To address missing data in our regional dataset, we employ a multi-stage imputation strategy that leverages available information at different geographical aggregations, from NUTS3 up to national (NUTS0) averages (Little & Rubin, 2019). This approach maintains data consistency while reducing bias due to missing values, following established principles for handling missing data in regional analyses. First, we apply two standard imputation techniques—Last Observation Carried Forward (LOCF) and Next Observation Carried Backward (NOCB)—to impute missing data within each region (NUTS3 level) over time. LOCF fills missing values with the last available observation, while NOCB fills them with the next available observation in the time series. This approach is commonly used in longitudinal datasets to retain temporal trends without introducing external information (Carpenter et al., 2023). After the initial temporal imputation, we use a systematic, hierarchical approach to aggregate data from higher NUTS levels (NUTS2, NUTS1, and NUTS0) for any remaining missing values:

By employing this multi-stage imputation strategy, we ensure that missing data is filled in a context-sensitive manner, respecting regional structures and temporal trends. This approach combines traditional imputation techniques (LOCF, NOCB) with hierarchical aggregation, making it well-suited for multi-level regional datasets (Rubin, 1987). The result is a more complete dataset that maintains consistency across different geographical levels and years, which is essential for robust and reliable regional analyses.

3.2 Qualitative Analysis: Case Studies

The case studies in this research aim to offer a comprehensive exploration of territorial exaptive resilience in the EU's eastern border regions. Five regions were purposefully chosen to reflect the diverse spectrum of borderlands in this area, each grappling with distinct challenges and opportunities arising from geopolitical shifts, environmental crises, and socio-economic disruptions (Seawright & Gerring, 2008).

3.2.1 Case Selection and Justification

The chosen case studies encompass a variety of EU eastern border regions, highlighting their unique features, resources, and obstacles. This varied selection facilitates a nuanced comparative analysis, enabling insights into the complex dynamics of territorial exaptive resilience and revealing both shared trends and regional particularities in responses to adversity (Seawright & Gerring, 2008).

The five selected case study regions are:

1. Maramureş County, Romania: This country borders Ukraine and is characterized by a mix of rural and urban areas, with a strong focus on agriculture and tourism. It has faced challenges related to population decline, limited accessibility, and the impact of the war in Ukraine on cross-border trade and mobility.
2. Lapland Region, Finland: Bordering Sweden, Norway, and Russia, this region is known for its vast natural resources, unique Arctic environment, and the presence of indigenous Sámi communities. It has experienced the effects of climate change, geopolitical tensions with Russia, and the need to diversify its economy beyond traditional industries.
3. Szabolcs-Szatmár-Bereg County, Hungary: Located on the border with Ukraine and Slovakia, this region has a diverse ethnic composition and a history of cross-border cooperation in fields such as education, culture, and environmental protection. It has been impacted by the refugee crisis and the need to enhance its innovation capacity and institutional quality.
4. Olsztyn Region, Poland: Situated on the border with Russia (Kaliningrad Oblast) and close to the Baltic Sea, this region has a significant potential for renewable energy, tourism, and green technologies. It has faced the challenges of managing the environmental impact of

economic activities, improving its transport infrastructure, and adapting to the changing geopolitical context.

5. Vilnius County, Lithuania: Bordering Belarus, this region includes the capital city of Vilnius and is known for its strong ICT sector, vibrant start-up ecosystem, and well-developed research and innovation infrastructure. It has experienced the effects of the political tensions with Belarus, the need to ensure energy security, and the importance of investing in human capital and digital skills.

These case studies were selected based on the following criteria:

- Inclusion of at least one Polish external border region
- Representation of multiple affected countries
- Heterogeneity in the development levels of the regions
- Inclusion of at least one region bordering Ukraine, one bordering Russia, and one bordering another post-Soviet country (Belarus or Moldova)

Table 3 summarizes the key characteristics of the selected case study regions:

Table: Key characteristics of the regions

Region	Country	Bordering Countries	Key Characteristics
Maramureş County	Romania	Ukraine	Rural-urban mix, agriculture, tourism, population decline, accessibility
Lapland Region	Finland	Sweden, Norway, Russia	Natural resources, Arctic environment, indigenous communities, climate change, economic diversification
Szabolcs-Szatmár-Bereg County	Hungary	Ukraine, Slovakia	Ethnic diversity, cross-border cooperation, refugee crisis, innovation capacity, institutional quality
Olsztyn Region	Poland	Russia (Kaliningrad Oblast)	Renewable energy, tourism, green technologies, environmental management, transport infrastructure
Vilnius County	Lithuania	Belarus	ICT sector, start-up ecosystem, research and innovation, political tensions, energy security, human capital

These varied case studies offer a deep insight into the multifaceted aspects of territorial exaptive resilience, shedding light on the distinct challenges and opportunities encountered by border regions along the EU's eastern frontier. By exploring how these areas have responded to recent crises and disruptions, the analysis provides meaningful lessons and practical strategies for enhancing resilience and adaptability in other border regions confronting comparable issues.

3.2.2 Data Collection

The case studies employ a multi-method approach to data collection, combining semi-structured interviews with key stakeholders, analysis of strategic documents such as regional development plans, and a review of relevant academic literature on the characteristics of the selected regions (Yin, 2014). This triangulation of data sources ensures a comprehensive and balanced perspective on the challenges and opportunities faced by border regions.

Semi-structured interviews are conducted with a diverse range of stakeholders, including representatives from local and regional authorities, civil society organizations, business associations, and academia. The interviews are guided by a flexible protocol that covers key themes related to territorial exaptive resilience, such as the perception and evolution of regional assets and capabilities, experiences and impacts of cross-border cooperation, responses to geopolitical changes and adaptation

strategies, and examples of creative and unconventional use of resources (Bryman, 2012; Kvale & Brinkmann, 2009).

3.2.3 Data Analysis

The analysis of qualitative data follows a flexible approach inspired by grounded theory, involving an iterative process of interepretation and comparison (Charmaz, 2014; Corbin & Strauss, 2015). The interview data and documentary evidence are organized and summarized using a grid system, where broad categories and themes are identified and refined through a process of constant comparison within and across cases (Ritchie & Lewis, 2003). The summarized data and emerging themes are then used to develop a coherent narrative for each case study, highlighting the specific context, challenges, and exaptive practices employed by the selected regions. The case study narratives are structured around a flexible template that allows for variations and adaptations based on the unique features and experiences of each region (Yin, 2014). Finally, a comparative analysis is conducted across the case studies to identify common patterns, differences, and lessons learned regarding territorial exaptive resilience in the EU's eastern border regions. This comparative analysis involves a process of cross-case synthesis, where the findings from each case are systematically compared and integrated to generate higher-level insights and propositions (Yin, 2014; Eisenhardt, 1989).

4 Results

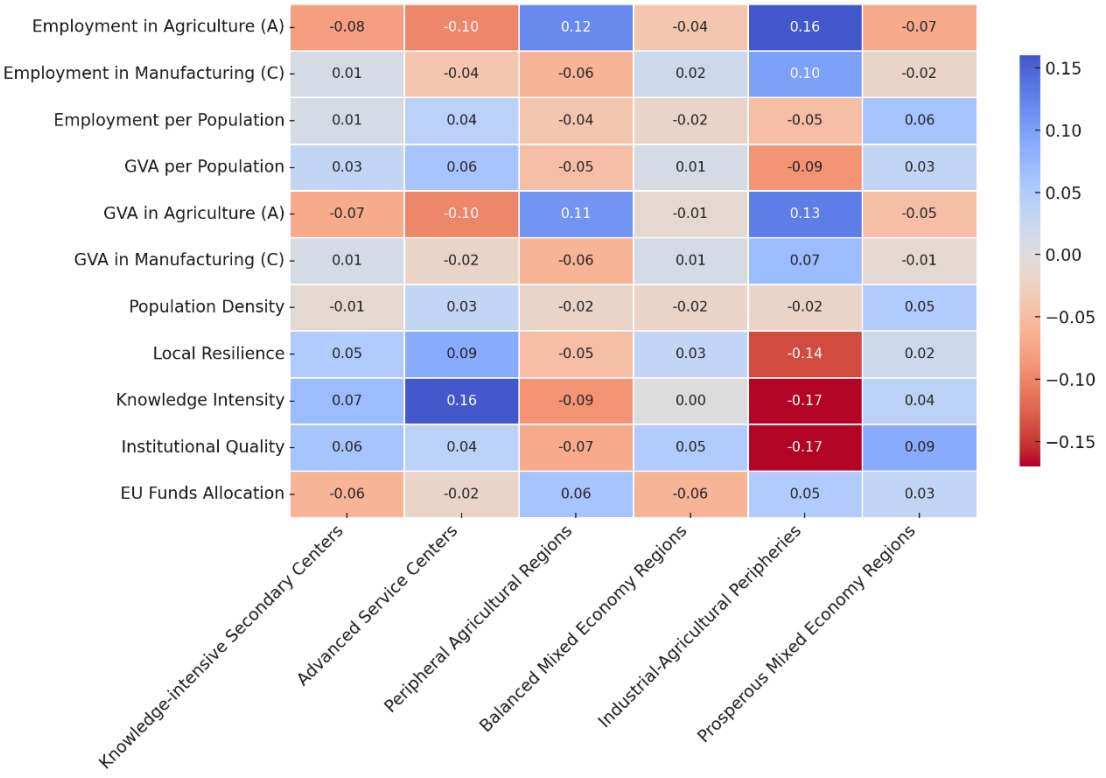
4.1 Classifying European Regions - Territorial Exaptive Resilience Capacity Classes

CLASSIFYING EUROPEAN REGIONS

European regions display significant structural diversity, with advanced service-oriented and knowledge-intensive clusters dominating in Western Europe, while Eastern European regions, except for capitals, are primarily industrial-agricultural peripheries with structural weaknesses and limited resilience capacities.

Understanding the structural position of regions is pivotal for assessing their current developmental trajectories and resilience capacities. In line with this our first step was to analyze how European regions can be grouped based on key indicators of economic, institutional, and social development. Using Latent Class Analysis (LCA), we identified six well-defined and interpretable classes that reflect the structural diversity across Europe.

Figure 4.1
Cluster characteristics - standardized values

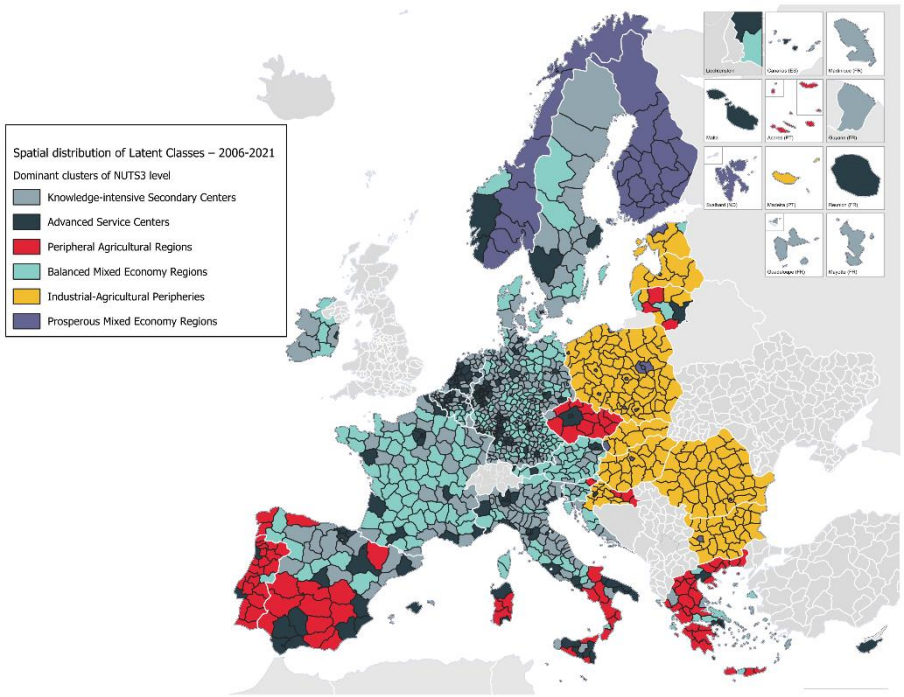


The "**Advanced Service Centers**" cluster comprises regions with the highest levels of GVA, local resilience, and knowledge intensity, coupled with a low share of agricultural employment and GVA. These regions are characterized by strong economic performance, underpinned by a conducive environment for the growth of high-skilled service sectors. Following closely, the "**Knowledge-intensive Secondary Centers**" cluster features regions with high local resilience, knowledge infrastructure, and institutional support, along with above-average GVA and low agricultural shares. These regions have a strong focus on knowledge-intensive economic activities, supported by a positive institutional environment. The "**Prosperous Mixed Economy Regions**" cluster stands out with the highest levels of employment and institutional support, accompanied by above-average GVA, local resilience, knowledge infrastructure, and EU funding. These regions have a diversified economic base, with low shares of both agricultural and manufacturing sectors, indicating their overall economic prosperity. Similarly, the "**Balanced Mixed Economy Regions**" cluster is characterized by average GVA levels, with slightly above-average local resilience and institutional support. However, these regions receive lower levels of EU funding compared to the other clusters. In contrast, the "**Peripheral Agricultural Regions**" cluster is marked by high agricultural employment and GVA shares, along with below-average overall employment, GVA, local resilience, and institutional support. Despite these challenges, these regions benefit from high levels of EU funding, indicating their reliance on external support for development. Finally, the "**Industrial-Agricultural Peripheries**" cluster represents the regions with the lowest levels of employment and GVA, as well as the weakest local resilience, institutional support, and knowledge sector. These regions have a strong presence of both industrial and agricultural sectors and receive high levels of EU funding, highlighting their peripheral status

The spatial distribution of the latent classes reveals significant differences between the regions of the Eastern European countries and the rest of Europe. With the exception of the capital regions some regions of Lithuania and Finland, all regions in Hungary, Latvia, Romania, Poland, and Estonia are classified as "Industrial-Agricultural Peripheries." This finding highlights the presence of structural

weaknesses and limited resilience capacities in these regions, which is consistent with the existing literature on the economic and institutional challenges faced by the EU's eastern border regions (Eurostat 2024, Endrődi-Kovács & Tankovsky 2023, Camagni et al. 2017, Chirodea et al 2020). Historically, these regions have been characterized by their peripheral location, limited economic power, and dependence on traditional sectors, making them more vulnerable to external pressures and less capable of generating new sources of growth.

Map 4.1
Spatial distribution of Latent Classes – 2006-2021



In stark contrast to the peripheral regions, the capital regions (Budapest, Bratislava, Warsaw, Riga, and Tallinn) of these countries, along with all regions in Finland, are classified as "Prosperous Mixed Economy Regions." (An exception to this is Vilnius, which is categorized as part of the 'Advanced Service Centers' cluster.) This classification suggests their ability to foster diversified economies and maintain robust institutional support, underlining the role of urban centers as engines of growth and resilience, even within the context of less developed regions.

Expanding the scope beyond the eastern border countries, the analysis highlights distinct regional patterns across Europe. In Southern Europe, a clear divide emerges, with regions aligning either with the "Agricultural Peripheries" or the "Advanced Service Centers" categories, underscoring their uneven development paths and diverse challenges. By contrast, Western Europe presents a more varied regional landscape, featuring "Balanced Mixed Economy Regions," "Knowledge-intensive Secondary Centers," and "Advanced Service Centers." This diversity reflects disparities in economic development, innovation capacity, and institutional quality, as well as differing trajectories of regional specialization and diversification (Boschma, 2015; Cortinovis et al., 2017).

In summary, significant territorial disparities can be observed across Europe. While Western European regions are characterized by a diverse mix of balanced, knowledge-intensive, and advanced

service-oriented economies, and Southern European regions exhibit a bifurcated pattern of either agricultural peripheries or advanced service centers, the regions in Central and Eastern European countries, with the exception of capital regions and Finland, are predominantly classified as industrial-agricultural peripheries, displaying structural weaknesses and limited resource endowments.

4.2 Spatial Distribution of Resilience Categories

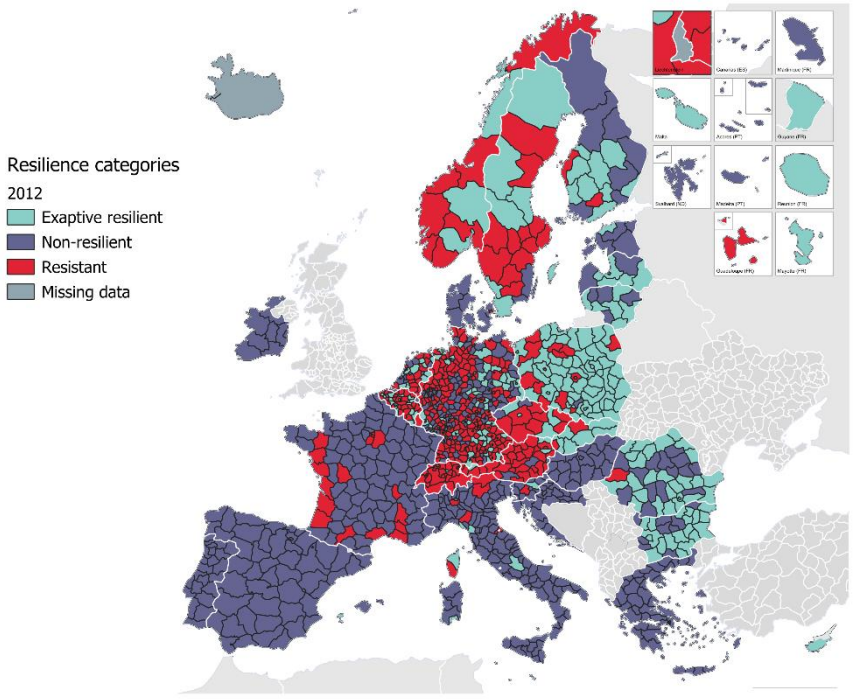
REGIONAL RESILIENCE PATTERNS IN EUROPE

The resilience patterns of European regions reveal stark contrasts: Western core countries consistently maintain resistance by preserving their economic structures, Eastern border countries and their regions typically respond to crises with exaptive resilience respond to crises by reorganizing their economies.

Having explored the diverse socio-economic landscapes of European regions, we now turn our attention to how these regions have weathered major crises in recent decades. This section examines the spatial and temporal patterns of resilience across Europe, utilizing the territorial exaptive resilience index (TERI) to analyze the heterogeneous responses of regions to various economic shocks and the evolution of their resilience capacities over time.

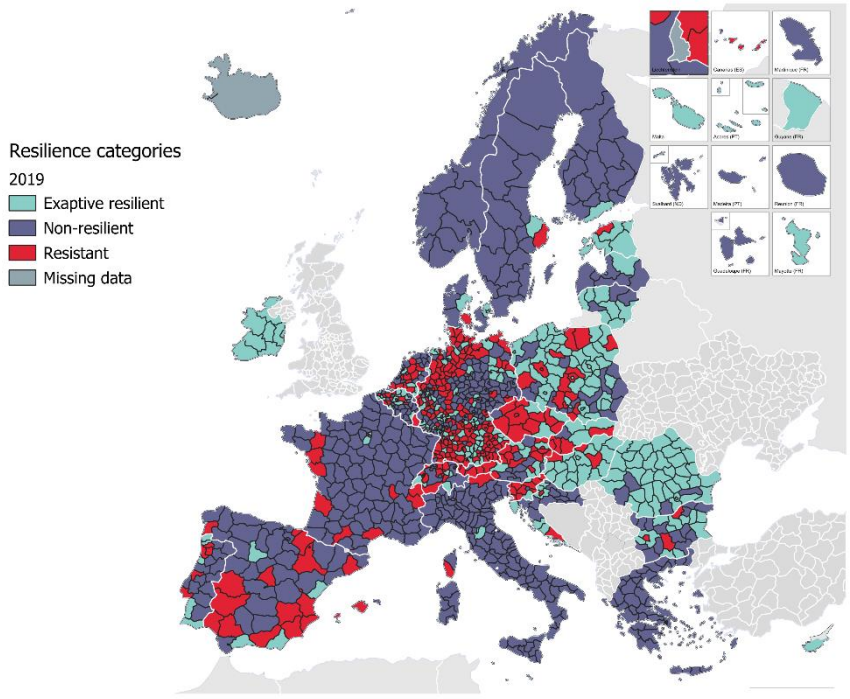
During the 2008 economic crisis (2006-2012), a clear geographical pattern emerged in terms of regional resilience. Non-resilient regions were predominantly concentrated in Southern Europe (Italy, Greece), France, Hungary, northeastern Finland, Ireland, Denmark, and certain regions of Romania, Bulgaria, Lithuania, Latvia, and Estonia, all struggling to maintain their economic performance and employment levels in the face of adversity. In contrast, resistant regions, demonstrating high resilience and stability, were mainly found in Switzerland, Germany, the Benelux countries, Austria, Czechia, the western coastal regions of France, southern and central Sweden, and western Poland. Exaptive resilient regions, combining high resilience with a strong capacity for reallocation, were observed in southern Finland, most regions of Poland and Slovakia, eastern regions of Lithuania and Latvia, border regions of Romania, and eastern regions of Bulgaria.

Map 4.2
Territorial resilience 2006-2012



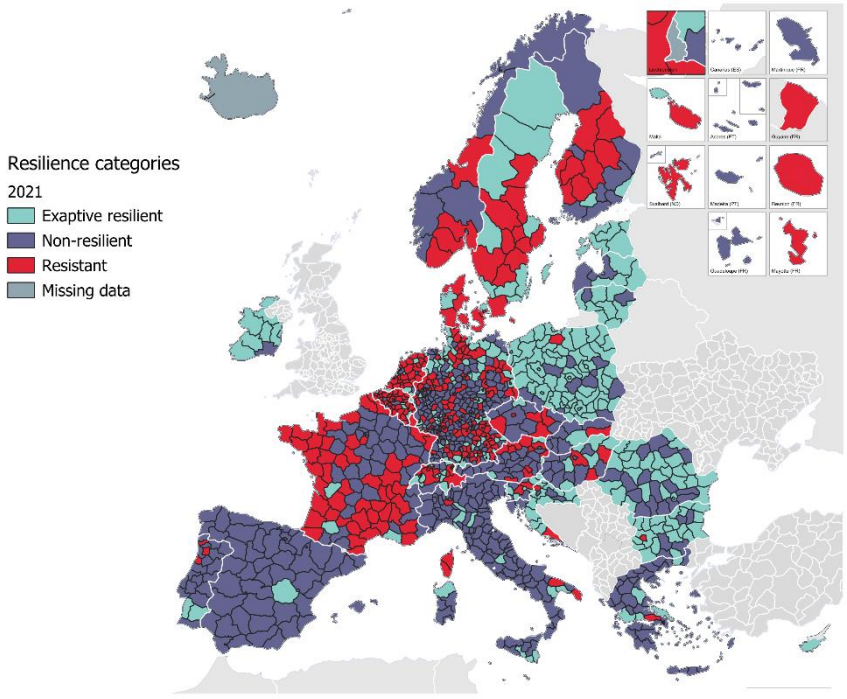
The EU economic boom period (2012-2019) saw a shift in the spatial patterns of regional resilience. Non-resilient regions were found in Southern Europe, France, most regions of the Nordic countries, and Latvia, indicating their inability to capitalize on the favorable economic conditions and achieve higher relative growth rates. Resistant regions, which managed to maintain stable growth during this period, were located in southern and western regions of Germany, western Czechia, and southern Spain. Notably, exaptive resilient regions emerged in Ireland, Eastern Europe and the Baltic countries, including most regions of Hungary and Romania, southern regions of Lithuania, central regions of Slovakia, and western and east-central regions of Poland. These regions demonstrated their ability to reallocate resources, adapt to the changing economic landscape, and foster growth during the boom period.

Map 4.3
Territorial resilience 2012-2019



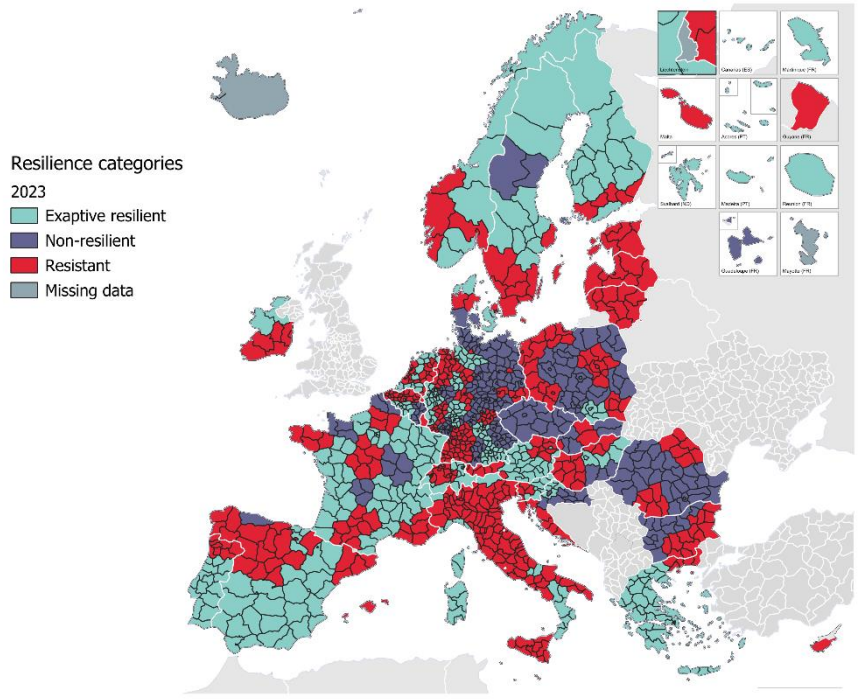
The COVID-19 pandemic (2019-2021) had a significant impact on regional resilience patterns across Europe. Non-resilient regions were prevalent in Southern Europe, particularly in Spain, Portugal, Italy, Greece, as well as central France, northern Finland, western Hungary, southern and western Austria, northwestern regions of Czechia, northwestern regions of Slovakia, and several southern regions of Romania. These regions struggled to cope with the economic disruptions caused by the pandemic. Resistant regions, which managed to maintain relative economic stability during the crisis, persisted in Germany, the Benelux countries, central Sweden and Finland, western and southern regions of France, and central Switzerland. Exaptive resilient regions, demonstrating the ability to restructure their economy and find growth opportunities, were found in the Eastern European countries, including Ireland, Estonia, Lithuania, border regions of Latvia, most regions of Poland, northeastern counties of Hungary, northern Sweden a significant part of Bulgaria, and a substantial portion of the border regions of Romania.

Map 4.4
Territorial resilience 2019-2021



The Russian invasion of Ukraine and the subsequent war (2021-2023) profoundly impacted the regional resilience landscape in Europe. Exaptive resilient regions, showcasing their ability to quickly respond to the geopolitical shock, emerged in Scandinavia, particularly in the northern regions, southern Portugal and Spain, southern Greece and Italy, eastern and western border regions of France, and central and east-central parts of Hungary, and southern Switzerland. Resistant regions, indicating their capacity to maintain economic stability despite the proximity to the conflict zone, were observed in the Baltic countries, western and central regions of Poland, western border regions of Romania with Ukraine, northern Italy, and northern Spain and Portugal, and central Switzerland. Non-resilient regions, hit hard by the disruptions in trade, energy supplies, and geopolitical tensions, were predominantly located in the eastern border areas of Central and Eastern Europe, including northeastern and southwestern regions of Romania, southern regions of Hungary, northeastern and central regions of Poland, and Czechia, often with strong economic ties to Russia and Ukraine.

Map 4.5
Territorial resilience 2021-2023



The analysis of territorial exaptive resilience in European NUTS3 regions during the examined periods reveals a striking contrast between the resilience patterns of Western core countries and the Eastern border regions. The results consistently show that regions of Germany, the Benelux countries, and Austria have been predominantly resistant to economic shocks, maintaining their stability and growth trajectories. In contrast, the Eastern border regions, despite their historically disadvantaged position, have demonstrated a remarkable capacity for exaptive resilience, adapting to the challenges posed by recent crises.

Beyond these spatial contrasts, the data also underscore the temporal variability of resilience. Regions do not respond uniformly to each crisis; rather, their capacity to resist or adapt can shift depending on the type of challenge they face. This variability suggests that different types of crises may activate distinct adaptive capabilities in regions, based on their specific structural endowments, policy responses, and institutional capacities.

For instance, the contrasting resilience patterns of Southern European and Nordic regions during the 2008 financial crisis and the COVID-19 pandemic point to the differential impact of economic and public health emergencies. Southern European regions, with their reliance on tourism and service-oriented economies, may have been more vulnerable to the demand shocks and travel restrictions imposed during the pandemic. In contrast, Nordic regions, with their robust welfare states, digitalized public services, and flexible labor markets, may have been better equipped to manage the health and social challenges of the crisis. Sweden's unique approach to pandemic management, which avoided strict lockdowns and relied on voluntary social distancing, may have contributed to its relative economic resilience during this period.

Similarly, the varying resilience of Eastern border regions in the face of geopolitical pressures highlights the role of trade networks, energy dependencies, and political alliances in shaping regional adaptability. Regions with diversified export markets and energy sources may have been less affected by the disruptions caused by the Russian invasion of Ukraine, compared to those with strong

economic ties to the conflict zone. Moreover, regions with a history of cross-border cooperation and institutional learning may have been better positioned to navigate the complex political and social challenges posed by the crisis.

4.3 Econometric modell

DRIVERS OF REGIONAL RESILIENCE

Resistance: Stability is promoted by local resilience, institutional quality, and knowledge infrastructure, which help regions maintain their economic structure during crises.

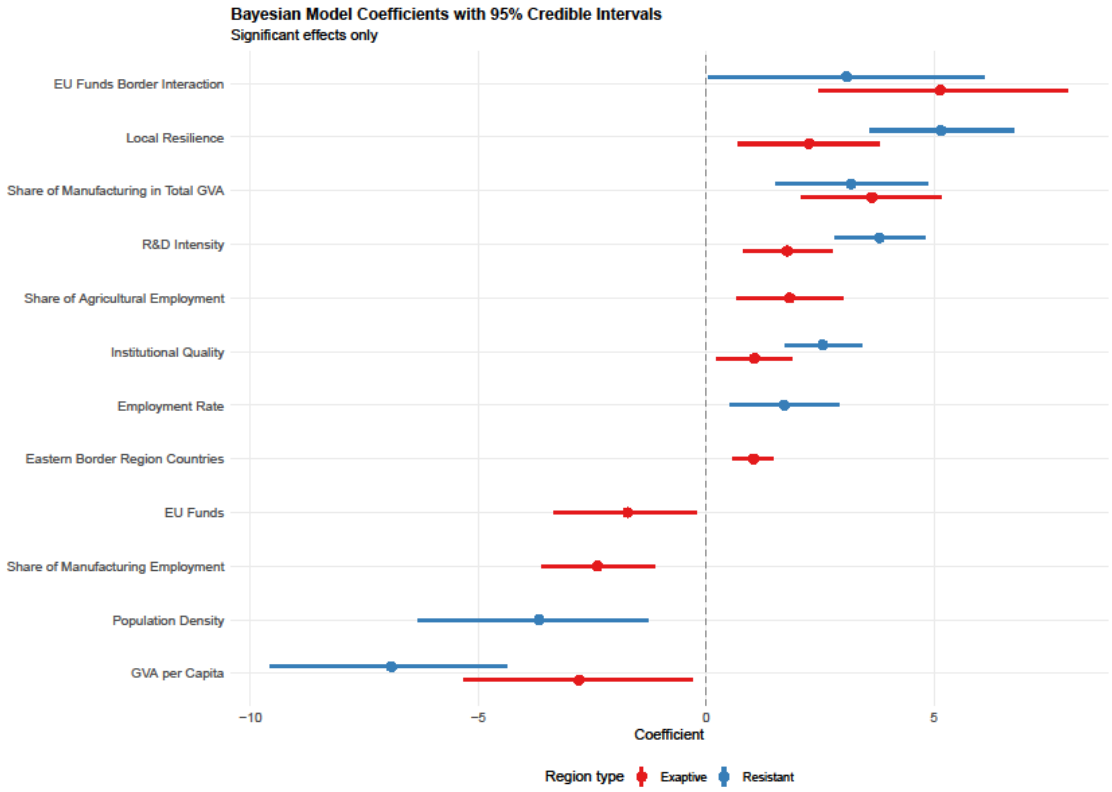
Exaptive Resilience: Alongside local resilience, institutional quality, and knowledge infrastructure, factors such as EU funding, cross-border cooperation, and sectoral shifts in manufacturing and agriculture also contribute to enabling regions to respond exaptively to challenges.

The observed differences in regional resilience patterns across Europe raise the question of what factors determine a region's ability to resist or adapt to economic challenges. To shed light on what enables some regions to resist or respond exaptively to economic shocks, we developed a Bayesian multilevel multinomial logistic regression model. This approach allows us to identify the drivers that distinguish resistant and exaptive resilient regions from non-resilient counterparts.

The model results reveal distinct yet overlapping sets of factors that influence whether a region is likely to exhibit resistant or exaptive resilience. For **resistant regions**, local resilience and institutional quality are paramount. Regions characterized by higher levels of social well-being, robust intra-regional connectivity, and effective governance are significantly more likely to maintain stability in the face of adversity. Knowledge infrastructure emerges as another critical determinant. Additionally, a strong manufacturing base—as reflected in its share of gross value added (GVA)—and higher employment rates bolster the ability of these regions to sustain economic performance.

In the case of **exaptive resilient regions**, a different set of dynamics comes into play. One of the most striking findings is the strong positive interaction effect between EU funding and border region status, highlighting the pivotal role of targeted support and cross-border cooperation in fostering exaptive capacity. This result underscores the importance of EU funding in promoting regional resilience, especially in border regions. Furthermore, our analysis reveals that regions in Eastern Border Region Countries are more likely to be classified as exaptive resilient, confirming the prevalence of exaptive patterns in these areas. While knowledge infrastructure, local resilience and institutional quality remain important for exaptive regions, their impact is less pronounced compared to resistant regions. The role of the manufacturing sector in exaptive regions is more nuanced. A higher share of manufacturing in gross value added increases the likelihood of being exaptive resilient, suggesting that a more productive and technologically advanced manufacturing sector is beneficial. However, a higher share of manufacturing employment has the opposite effect, indicating that exaptive regions may be better served by a manufacturing sector that relies less on traditional, labor-intensive industries. Interestingly, the agricultural sector appears to play a more significant role in the resilience of exaptive regions, hinting at the potential for traditional sectors to contribute to regional resilience through adaptation and diversification strategies.

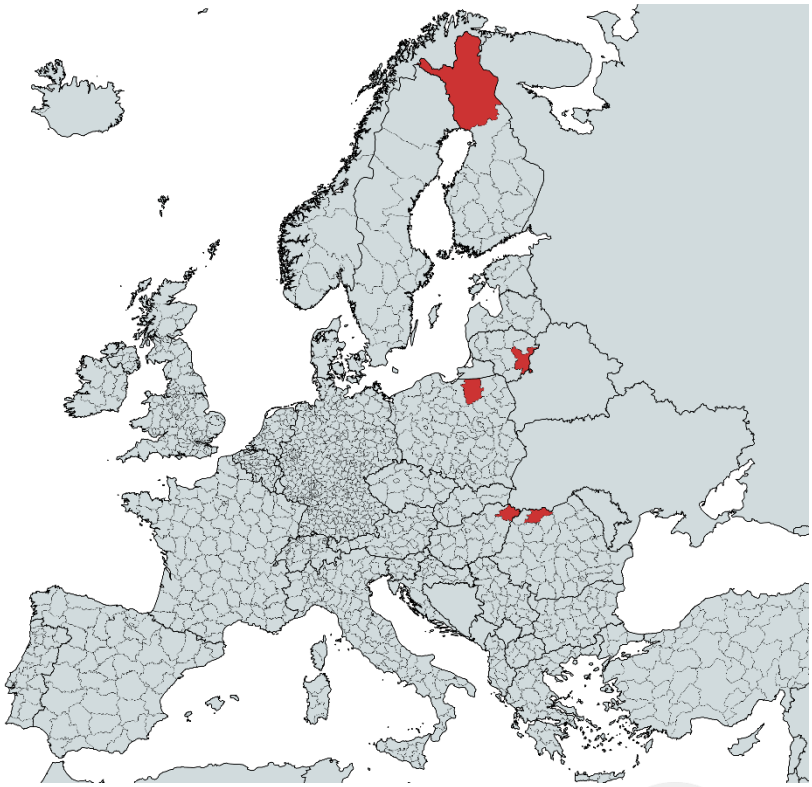
Figure 4.2
Econometric modell – Coefficients



4.4 Case studies

The quantitative analysis and econometric model have highlighted general trends and patterns in territorial (exaptive) resilience across the regions of Europe. To delve deeper into the specific exaptive practices and uncover the mechanisms and conditions underpinning their integration, it is crucial to examine the unique contextual factors that shape resilience outcomes in different regions. To investigate these dynamics, a series of case studies were carried out, examining diverse regions with distinct economic, cultural, and historical contexts. These studies offer comparative insights into the territorial aspects of resilience and provide valuable guidance for policymakers seeking to foster adaptation and transformation in border regions. The following sections summarize the key features and findings of each case, with a particular focus on their policy implications.

Map: Studied Regions



4.4.1 The case of Olsztyński subregion in Poland

TERRITORIAL EXAPTIVE RESILIENCE INDEX

The Olsztyński subregion demonstrated exaptive resilience by shifting focus from cross-border reliance to leveraging natural assets, EU funding, and new development opportunities amid geopolitical crises.

4.4.1.1 Overview of the border region

The Olsztyński subregion (NUTS3 level), part of the Warmińsko-Mazurskie region (NUTS2) in northeastern Poland, covers an area of over 10,000 square kilometers and is inhabited by approximately 590,000 people. Over the last two decades, the population has decreased by 20,000 (3.5%). The subregion includes 21 cities, home to about 60% of the total population, slightly below the Polish average. Olsztyn, the largest city and capital of the region, has experienced a slight decline in population from 174,000 in 2004 to 167,000 currently. The main economic sectors include the food, furniture, wood, and tire industries, as well as tourism. Olsztyn, with its university, plays a significant role in education and transportation. The subregion borders the Russian Federation's Królewiecki Oblast (former Kaliningrad Oblast) to the north.

4.4.1.2 Impact of Crises

The closure of local border traffic with the Królewiecki Oblast in 2016 and the subsequent deterioration of Polish-Russian relations have frozen developing cross-border relations. Russia's full-scale invasion of Ukraine has further isolated the region's north, accelerating depopulation. These crises have highlighted the need for stronger ties with other Polish regions to improve the subregion's accessibility. Olsztyn, as the "last stop" for inhabitants before leaving the region, plays a crucial role in reducing peripherality and weakening depopulation trends by enhancing its attractiveness as a place to work and conduct business.

4.4.1.3 Leveraging Local Resources for Exaptive Resilience

The region's important assets include its natural elements, such as lakes, forests, clean air, and hilly terrain, which form the basis for developing sailing, cycling, agritourism, and broader ecosystem services. The full-scale invasion of Ukraine by Russia has led to a decrease in tourist and investments (climate) numbers due to perceived threats and disinformation.

The increased interest in border areas from European institutions as a result of the war allowed a shift from a "waiting mode" for better cooperation with Russia to a "searching for new opportunities mode," where the focus is on leveraging external European resources and endogenous potentials rather than relying on the border and abroad as development resources. This change in thinking is a kind of exaptive resilience, using the geographical location for other development purposes.

After the almost complete closure of the border with Russia, many small businesses ceased to operate. In connection with this, potential directions of development will stronger focus on ecotourism, senior tourism, water economy, healthy food, healthy living (spa), and generally ecosystem services.

4.4.1.4 Cross-Border Ties and Cooperation

The region's experience in cross-border contacts with entities of the Królewiecki Oblast, both positive and negative, has contributed to building institutional capital, which should be further strengthened through cooperation with other partners. Deepening cooperation with the Baltic states to exchange experiences in combating Russian propaganda, information warfare, and other threats presents an opportunity to fill the gap left by the suspension of cross-border cooperation with the Królewiecki Oblast. Bilateral cooperation within the framework of Interreg CBC Poland-Lithuania, South Baltic, and other Baltic Sea Basin programs is crucial, particularly for their ease of potential renegotiation in times of geopolitical changes. However, small municipalities with limited staff and budgets may face difficulties in achieving this cooperation, necessitating external organizational and financial support (ia. due to lower tax income). According to entrepreneurs, a greater share in cross-border cooperation projects can facilitate the exchange of experiences with Baltic Sea regions in running companies, the possible use of benefits from different operating costs, and the expansion of business markets. This approach can help maintain cross-border and transnational cooperation after the end of project financing from European funds, enabling public institutions and entrepreneurs to reuse their cooperation skills and become more capable of adapting and strengthening the resilience of regions in the long term.

4.4.1.5 New Potential Development Pathways

Due to the suspension of cooperation with the Królewiecki Oblast and the loss of EU funds from the Poland-Russia Programme, some share of funds are being redirected to the Poland-Lithuania Programme (road infrastructure, crisis management, border guard, fire brigade, tourism) and the South Baltic (support for innovation, labor market). This process is a chance for fostering new relations, especially with the South Baltic regions, but need time to adapt to new cooperation directions. In the social dimension, building linking social capital that connects the region's inhabitants with institutions based on high mutual trust can be an adaptation strategy to external shocks, increasing the level and sense of security within cooperating police, scouts, territorial protection forces, local governments, and residents. In the economic and infrastrutural dimension, partial independence from external energy suppliers, including the development of distributed solar and wind energy, is important in the context of geopolitical changes, providing new jobs and contributing to economic renewal. Examples of creative use of resources in the Olsztyński subregion during the pandemic crisis include the development of dispersed hotel forms, the conversion of free warehouse space into production facilities or distribution centers, and the renting of summer houses in small towns to employees from large Polish cities for remote work. These changes in employee behavior under hybrid work can be scaled up to other peripheral regions and future crises.

4.4.1.6 Challenges and Lessons Learned

The Olsztyński subregion faces several challenges in building resilience. The sealing of the border has led to a decrease in the flow of people and goods, a decrease in investment and economic activity near the border, and a decrease in the level of security. These processes, combined with an increase in hybrid attacks and military threats, have reduced the region's resilience to external turbulence. To address these threats, several anticipatory actions are emphasized, such as increasing social resilience to disinformation, ensuring the continuity of administration and key state processes, developing contingency plans and backup energy sources, raising the ability to respond to mass uncontrolled migrations, and enhancing the capacity of the civilian health service system. Ensuring the continuity of communication and telecommunications systems in crisis situations, along with an adequate state of spare resources, is also crucial.

4.4.1.7 Implications for EU Cohesion Policy and Cross-Border Cooperation

A special challenge in the context of cohesion policy is to regain its original development role. Cohesion policy should be characterized by an individualized territorial approach, directed by and to local governments and residents. On one hand mainstream interventions, including the Eastern Poland

Programme should have special earmarked funds for border areas, and and more local context should be taken into account. On the other, terminated external cooperation with agressive neighbour should be replaced by the new internal (EU borders) Interreg cooperation tool for the regions bordering Russia. In border areas, subsidies for entrepreneurs should be maintained due to concerns about locating investments in these areas. The importance of investments in hospitals, linear investments, and improving the quality of public services in regions bordering aggressors is also emphasized. The challenge in large urban centers, including the capitals of regions with the eastern border of the EU, is to create favorable conditions for the development of young and talented people to stop emigration to other centers. A good example can be initiative „Startup Platforms for New Ideas" within Eastern Poland Programme (ERDF) which is a earmarked support for individuals who want to set up and manage their company in the macroregion of Eastern Poland and develop it on the national and international market. Eligible ideas will be developed through comprehensive incubation programmes in the Start-up Platforms. The best start-ups will receive non-refundable subsidies for continued business development. .

4.4.1.8 Conclusion

The case study of the Olsztyński subregion highlights the challenges and opportunities faced by border regions in the context of geopolitical changes and crises. The region has experienced significant impacts from the closure of local border traffic with the Królewiecki Oblast and Russia's invasion of Ukraine, leading to increased peripherality, depopulation, and reduced resilience to external turbulence. However, the region also possesses valuable assets, such as its natural resources and the potential for developing ecosystem services, which can be leveraged for exaptive resilience. Strengthening cooperation with other Polish regions, deepening ties with the Baltic states, and redirecting EU funds towards new development paths are crucial strategies for adapting to changing circumstances.

4.4.2 The case of Maramures county in Romania

TERRITORIAL EXAPTIVE RESILIENCE INDEX

Maramureș County exemplifies exaptive exaptive resilience by repurposing its natural and cultural assets, implementing circular economy initiatives, and leveraging community engagement to address challenges and foster sustainable development.

4.4.2.1 Overview of the border region

Maramureș County in northwestern Romania offers a compelling study of exaptive resilience in EU border regions. With a population of 454,000 as of 2021 and a diverse geography encompassing mountains, hills, and basins, the county's economic history spans agriculture, forestry, mining, and manufacturing. Over time, it has faced structural economic shifts, including a decline in mining and agricultural employment, alongside growing service and tourism sectors.

4.4.2.2 Key crises faced by the region

The collapse of the mining industry in the early 2000s left a legacy of unemployment, environmental degradation, and community dislocation in Maramureș. Contaminated sites and abandoned mines still pose health and ecological risks. The COVID-19 pandemic further disrupted key sectors like tourism and manufacturing, exposing systemic weaknesses in healthcare and digital infrastructure. The war in Ukraine brought an influx of refugees, testing local resources and cross-border networks..

4.4.2.3 Leveraging Local Resources for Exaptive Resilience

Maramureș has repurposed its natural and human assets to address challenges innovatively. The SPIRE project demonstrates the use of phytoremediation to clean contaminated soil while generating biomass for energy, showcasing circular economy principles[4]. Local communities actively participated in these efforts, gaining a renewed sense of agency and pride. Sustainable tourism initiatives have capitalized on the region's cultural heritage, gastronomy, and traditional crafts[5]. These projects leverage local expertise and diaspora involvement, fostering resilience and economic opportunities.

[4] This approach has also been emphasized in the Sustainable Development Strategy of Maramures County 2021-2027 – Policy P3.2b. which lists as desirable goals to monitor and improve the quality of environmental factors (noise, air, water, soil), and rehabilitate the industrial sites and contaminated lands.

[5] Generally ,in the region, there has been a significant increase in the tourism sector, namely in the evolution of accommodation units (touristic and agrotouristic boarding houses) in rural areas of Maramureș County since the 1990s. There has been a steady increase starting in 2003 and a significant peak reaching 226 units in 2017. Notable growth periods include 1999-2000 and 2016-2017, highlighting a sharp rise in interest for rural tourism infrastructure (Simion et al. 2018). The region has also been relatively successful in debouncing after the COVID-19 pandemic which significantly impacted the tourism sector(Fărcașiu 2024).

The SPIRE HUB, a repurposed building in Baia Mare, now supports eco-digital innovation and collaboration, utilizing a local digital currency to incentivize sustainable behavior.

4.4.2.4 Status of Cross-Border Ties and Cooperation

Maramureş's longstanding ties with Ukraine were initially strained by the war but have adapted to meet refugee needs. Local authorities and NGOs collaborated to provide humanitarian aid, while projects like the new border bridge highlight opportunities for enhanced future connectivity and cooperation. The region is well-positioned to play a role in Ukraine's post-war reconstruction, strengthening its strategic importance.

4.4.2.5 New Potential Development Pathways

Emerging pathways in Maramureş include expanding niche tourism, such as ecotourism and agrotourism, leveraging the region's natural and cultural heritage. The SPIRE project, however, offers a transformative model by combining environmental remediation with circular economy practices. Through phytoremediation, SPIRE addresses land contamination while generating biomass for renewable energy, showcasing how waste can become a resource. The project highlights the power of cross-sector collaboration, uniting municipalities, universities, NGOs, and businesses. The SPIRE HUB exemplifies this approach, serving as a platform for eco-digital innovation and sustainable community development. Scaling such initiatives to other sectors can diversify Maramureş's economy while ensuring sustainability, reinforcing its role as a model for adaptive resilience..

4.4.2.6 Challenges and lessons learnt

Structural issues like outward youth migration, skills mismatches, and governance gaps hinder long-term resilience. Dependence on external funding and insufficient planning lead to short-term project lifespans. Enhanced digital infrastructure, institutional reforms, and a focus on inclusive governance are critical to addressing these challenges. Empowering local communities and fostering trust in institutions are essential for sustained progress.

4.4.2.7 Implications for EU Cohesion Policy and cross-border cooperation

Maramureş's experience underscores the need for tailored EU Cohesion Policy approaches. Supporting border regions with flexible funding, capacity-building, and frameworks for experimentation is vital. Enhanced cross-border governance, peer learning, and integration of exaptive resilience principles can strengthen regional adaptability and cooperation. Encouraging innovation and knowledge-sharing across sectors will be key to sustainable development..

4.4.2.8 Conclusion

Maramureş exemplifies the potential of border regions to transform crises into opportunities through innovative practices, community engagement, and cross-border collaboration. By integrating local assets, fostering multi-level governance, and leveraging EU support, the county demonstrates how resilience can be built amidst adversity. Its lessons provide a roadmap for EU Cohesion Policy to empower border regions in driving sustainable and inclusive growth across Europe.

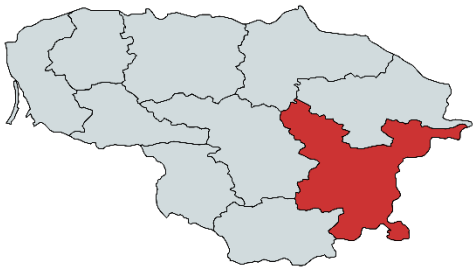
4.4.3 The case of Vilnius county in Lithuania

TERRITORIAL EXAPTIVE RESILIENCE INDEX

Vilnius County demonstrated exaptive resilience during the 2021 migration crisis by repurposing infrastructure, rapidly adapting public institutions, and integrating civil society networks to manage unprecedented irregular migration flows.

4.4.3.1 Overview of the border region

Vilnius County, a region in southeastern Lithuania, shares a 678.82 km border with Belarus, the longest among the three Lithuanian NUTS-3 regions bordering Belarus. Classified as both a NUTS-2 and NUTS-3 region, the county comprises eight municipalities, including Vilnius city municipality (the capital). The county is home to almost a third of Lithuania's population, with around 20% residing in Vilnius city. It is the most prosperous region in Lithuania, accounting for nearly half of the country's GDP. However, despite being the most economically developed county, it is characterized by strong economic disparities between Vilnius and the remaining municipalities, reflecting the general regional situation in Lithuania. The county is also diverse in terms of ethnic composition, especially regarding the Polish ethnic minority.



4.4.3.2 Key crises faced by the region

The county and the entire country faced significant challenges in dealing with several crises of global, national, or regional scale, including the opening of the Belarusian Astravec nuclear power plant in 2020, the influx of people fleeing the Belarusian regime following the fraudulent presidential elections in August 2020, the COVID-19 pandemic in 2021, the Russian-Belarusian exercise Zapad-2021, and Russia's war in Ukraine in 2022. However, the focus of this case study is on the irregular migration caused by Belarus, which started in summer 2021 and is still ongoing. The migration crisis marked a turning point for Lithuania, particularly due to the strategic instrumentalization of migration by the Belarusian regime. Unlike traditional migration flows, this situation involved the active facilitation of irregular migration through Belarus, targeting Lithuania and other bordering states. The influx of migrants occurred at an unprecedented scale and speed, with over 4,000 unauthorized entries reported in 2021 alone. The mixed nature of the migrant groups, including asylum seekers, economic migrants, and individuals seeking medical services or family reunification, complicated the crisis response. Lithuania adopted a firm approach, seeking to prevent uncontrolled migrant flows into the EU, employing deterrence and push-back tactics. Various resilience-building measures were taken by Lithuanian authorities, such as declaring a state of emergency, requesting help from EU institutions, introducing new legislation, increasing border protection, and establishing temporary housing.

4.4.3.3 Leveraging Local Resources for Exaptive Resilience

The 2021 migration crisis necessitated an immediate response from Lithuanian authorities to accommodate the sudden influx of migrants. The state and municipal authorities expanded existing centers and established additional sites across municipalities, repurposing various facilities, including previously unused or underutilized buildings, to serve as temporary accommodation centers. However, the scarcity of suitable facilities became evident, and the crisis exposed gaps in

coordination with non-governmental organizations (NGOs), which could have better contributed expertise in managing temporary accommodations. The migration crisis resulted in rapid adaptation across public institutions, with many taking on new roles and functions needed to respond to and manage the crisis. For example, the State Border Guard Service (VSAT) had to carry out functions not inherent to its role as a law enforcement agency, such as expanding housing facilities and providing basic medical, social, and legal services. The Ministry of the Interior coordinated emergency operations at the national level, while the Lithuanian Ministry of Foreign Affairs assumed a proactive role in engaging its diplomatic resources to address migration-related challenges. Various NGOs played a crucial role during the migration crisis, filling significant gaps in government capacity. The crisis catalyzed a shift in institutions' understanding of the value of integrating NGOs into crisis management frameworks. NGOs established a coordinated response mechanism and introduced new approaches, such as mobile team formats for providing humanitarian and social support.

4.4.3.4 Status of Cross-Border Ties and Cooperation

The migration crisis created a complex situation for Lithuania's cross-border relationships, leading to stronger alliances with certain EU neighbours and institutions while simultaneously cutting ties of cross-border cooperation with Belarus. Prior to the crisis, Lithuania and its regions maintained cross-border cooperation with Belarus in terms of border security and wider socio-economic cooperation. However, the crisis severely disrupted this cooperation, halting previously established frameworks for collaboration and affecting the local economy in border regions. Conversely, the crisis fostered stronger ties between Lithuania and Poland and other EU partners, with ongoing collaborative efforts on border security measures.

4.4.4 New Potential Development Pathways

The 2021 migration crisis in Vilnius County highlighted the need for adaptable infrastructure, stronger cross-border governance, and improved crisis management systems. Future development pathways include investing in multi-purpose facilities that can be repurposed during emergencies, enhancing cooperation with EU neighbors through joint border security initiatives, and addressing regional disparities by fostering inclusive economic growth. Strengthening digital crisis management tools, countering disinformation, and building resilient community networks are essential for preparedness. Flexible EU funding mechanisms and deeper integration of civil society into crisis frameworks will further enhance the region’s capacity to respond effectively to future challenges.

4.4.4.1 Challenges and Lessons Learnt

The 2021 migration crisis exposed several significant challenges for Lithuanian institutions, both at regional and national levels. These challenges included the overall preparedness for such a crisis, structural and systemic challenges, limited capacity of the regions, lack of available infrastructure, governance and coordination gaps, and issues with information provision and IT systems. Following these challenges, some valuable lessons were learned, and changes are being implemented.

4.4.4.2 Implications for EU Cohesion Policy and Cross-Border Cooperation

The experience of Lithuania during the migration crisis showcased the importance of EU support in addressing the challenges posed by the crisis and improving the resilience of the country and its regions. This support included assistance provided by various EU institutions and agencies, as well as financial support through EU funds such as the Asylum, Migration and Integration Fund (AMIF), Internal Security Fund (ISF), and Border Management and Visa Instrument (BMVI). The case study highlights the need for further support for the convergence of the regions, more flexible ESIF funds, development of multi-purpose infrastructure, capacity building through the exchange of best practices and peer-to-peer learning, investment in civil society organizations, and support for efforts to counter disinformation, particularly in border regions.

4.4.4.3 Conclusions

Lithuania's response to the 2021 migration crisis from Belarus highlights a multifaceted approach to managing unprecedented irregular migration flows. The case illustrates how central and local authorities had to implement various actions at an unprecedented speed, successfully ensuring the country's security while balancing security-driven responses with humanitarian concessions. The case shows how the country and border regions can demonstrate exaptive resilience through effective mobilization and repurposing of resources, rapid adaptation of public institutions, and leveraging civil society networks. However, materializing exaptive resilience to a larger extent was strained by various challenges at different levels, including the unpreparedness of the migration system, limited capacity of the regions, and resistance from local communities. The crisis underscored critical areas for improvement in preparedness, coordination, and infrastructure resilience across Lithuania's public institutions, with several actions at various governance levels and policy fields already being taken to address these issues.

4.4.5 The case of Szabolcs-Szatmár-Bereg county in Hungary

TERRITORIAL EXAPTIVE RESILIENCE INDEX

Szabolcs-Szatmár-Bereg County exemplified exaptive resilience during the Ukrainian refugee crisis by repurposing local resources, fostering grassroots solidarity, and leveraging hidden competencies within its population, such as multilingualism and cultural mediation

4.4.5.1 Overview of the border region

Szabolcs-Szatmár-Bereg County, situated in northeastern Hungary and bordering Ukraine, has been at the forefront of the humanitarian response to the refugee crisis triggered by the war in February 2022. The region's proximity to the conflict zone and its well-established cross-border ties have made it a focal point for the influx of Ukrainian refugees. As a border region, Szabolcs-Szatmár-Bereg County has long faced challenges related to its peripheral location, such as limited economic opportunities and outmigration of young people. However, its border status has also endowed it with unique resources and connections, such as a rich history of cross-cultural exchange and an infrastructure for cross-border cooperation, which have proven crucial in enabling the region to respond effectively to the sudden influx of refugees.

4.4.5.2 Key crises faced by the region

The outbreak of the war in Ukraine in February 2022 triggered a massive refugee crisis, with hundreds of thousands of people fleeing the conflict and seeking safety in neighboring countries, including Hungary. The sudden arrival of refugees intensified existing regional challenges, including limited economic opportunities and social inequalities. The county had to rapidly mobilize to address the refugees' needs while managing the pressures on local communities.

4.4.5.3 Leveraging local resources for exaptive resilience

The county displayed exaptive resilience by repurposing existing facilities for refugee housing, such as cultural centers and unused buildings. Local civil society organizations and faith-based groups were instrumental in coordinating relief efforts, leveraging their networks to mobilize volunteers and resources. Multilingual locals, particularly ethnic Hungarians from Transcarpathia, acted as cultural mediators, enhancing communication and integration. Innovative collaborations among municipalities, NGOs, and the private sector further strengthened the response..

4.4.5.4 Status of cross-border ties and cooperation

The refugee crisis highlighted both the strengths and challenges of cross-border relations. While formal cooperation mechanisms with Ukraine were disrupted due to tightened border controls, grassroots solidarity flourished. Personal, familial, and business relationships facilitated aid, with locals

treating refugees as acquaintances. However, the crisis also altered demographic compositions, with many ethnic Hungarians from Transcarpathia relocating to Hungary and concerns rising about the diminishing Hungarian community in Transcarpathia. Shared cultural identities played a crucial role in fostering solidarity, but tensions emerged due to differences in financial means and cultural norms between new arrivals and long-time residents.

4.4.5.5 New Potential Development Pathways

The crisis revealed opportunities for fostering long-term resilience through improved cross-border infrastructure and collaboration. Simplifying border crossings and developing joint economic initiatives, such as agriculture and eco-tourism, could strengthen ties. Investing in multilingual education, cultural exchange programs, and targeted funding for crisis preparedness can create a more integrated and adaptable border region. Expanding cross-sectoral partnerships and enhancing grassroots engagement are vital for sustainable development..

4.4.5.6 Challenges and lessons learnt

Significant challenges include the need for predictable financial and institutional support from national and EU authorities. The strain on local resources highlighted gaps in infrastructure and social services. Social tensions emerged, particularly concerning marginalized groups like the Roma, emphasizing the importance of equitable support and anti-discrimination efforts. Coordination among various actors—government, NGOs, international organizations—was sometimes fragmented, underscoring the need for more effective governance mechanisms.

4.4.5.7 Implications for EU Cohesion Policy and cross-border cooperation

The county's experience offers lessons for EU Cohesion Policy. Border regions need targeted funding streams, stronger cross-border governance, and enhanced social infrastructure. Supporting civil society and empowering local actors can enable more agile and sustainable responses. Fostering cross-border economic integration and resilience-oriented programs, such as cultural exchanges and joint development projects, is essential for long-term stability and growth.

4.4.5.8 Conclusions

Szabolcs-Szatmár-Bereg County's response to the refugee crisis exemplifies exaptive resilience through creative resource repurposing and robust grassroots cooperation. While challenges remain, such as financial constraints and social inequalities, the region demonstrated the potential of border communities to adapt and innovate under pressure. EU Cohesion Policy must support such regions with tailored funding, improved governance, and a focus on resilience-building initiatives, ensuring border areas are equipped to navigate future crises effectively.

4.4.6 The case of Lapland region in Finland

TERRITORIAL EXAPTIVE RESILIENCE INDEX

Lapland showcases exaptive resilience by expanding tourism beyond winter seasons, utilizing Sami cultural knowledge for sustainable development, diversifying its economy with bioeconomy initiatives and Arctic innovations, and adapting to NATO's growing strategic presence amidst geopolitical and environmental challenges.

4.4.6.1 Overview of the Border Region

Lapland, Finland's largest region, spans one-third of the country and borders Sweden, Norway, and Russia. The region shares a strategically significant 380-kilometer border with Russia, which has gained increased attention since Finland's 2024 NATO accession. Lapland is sparsely populated, with 180,000 residents and a density of two people per square kilometer. The landscape transitions from Arctic tundra in the north to boreal forests in the south, sustaining traditional livelihoods such as reindeer herding, fishing, and forestry. While these industries remain relevant, tourism has emerged as the primary economic driver, leveraging the region's natural beauty and Sami cultural heritage. Lapland contributes 7% to Finland's exports, though 94% of its enterprises are microbusinesses. EU programs like Interreg Nord support sustainable development, though geopolitical tensions with Russia pose challenges to cross-border cooperation.

4.4.6.2 Key Crises Faced by the Region

Lapland has experienced significant shifts due to mechanization, outmigration, and climate change. Forestry and mining employ fewer people, while Arctic warming, surpassing global averages, threatens industries like forestry and tourism, prompting adaptations such as artificial snow-making. The COVID-19 pandemic further impacted tourism, exposing its vulnerability to global disruptions and emphasizing the need for diversification beyond seasonal dependence. Geopolitical tensions with Russia have disrupted infrastructure projects, such as an Arctic railway, and strained cross-border ties. This situation has been further complicated by the Russian military base at Alakurtti, located just 50 kilometers from the Finnish border town of Salla, which represents a significant strategic concern for the region. In response to these developments, Finland's NATO membership has increased military activity, though this has also raised environmental concerns. Moreover, global market shifts and reliance on export-oriented industries further underscore the region's economic vulnerabilities.

4.4.6.3 Leveraging Local Resources for Exaptive Resilience

Lapland exemplifies exaptive resilience by repurposing natural and cultural assets. Nature-based tourism and the bioeconomy have complemented declining traditional industries. Tourism, initially focused on winter experiences, is increasingly exapted to other seasons, offering autumn activities, year-round wellness retreats, and eco-tourism. Investments in bioenergy, biofuels, and wood-based

textiles diversify forestry outputs while promoting sustainability. Sami entrepreneurs contribute through cultural heritage initiatives, including guided tours, traditional food products, and design. Their indigenous knowledge not only supports Arctic adaptation strategies but also provides valuable insights for NATO operations in the region, enhancing sustainability and local engagement. This strategic value has been further emphasized as NATO's presence has expanded, with Ivalo now hosting the Alliance's closest base to mainland Russia, while discussions continue about establishing a new NATO headquarters in either Rovaniemi or Sodankylä. Beyond these military developments, the region's educational and research institutions continue to strengthen Lapland's position in cold-climate innovation, including circular economy practices and Arctic technologies.

4.4.6.4 Status of Cross-Border Ties and Cooperation

The war in Ukraine and resulting geopolitical tensions have disrupted Lapland's long-standing cross-border ties, particularly with Russia. Historical collaboration through initiatives like the Barents Euro-Arctic Cooperation has stalled. The Arctic Council's diminishing influence has created a void in regional governance, while NATO's growing presence, exemplified by its largest military exercise near Rovaniemi in Autumn 2024, has reshaped regional dynamics. Increased military presence has highlighted Lapland's strategic importance while raising concerns about environmental impacts. The region has shifted its focus toward Nordic and EU partnerships, emphasizing infrastructure, environmental protection, and cultural exchange. EU cohesion funds have supported these efforts, but their impact remains modest compared to more centralized funding in Eastern Europe. Experts stress the need for tailored EU policies addressing northern peripheries' unique challenges.

4.4.6.5 New Potential Development Pathways

Geopolitical shifts prompt Lapland to strengthen ties with Nordic and EU neighbors, focusing on environmental protection and climate adaptation, though Russia's withdrawal hampers Arctic cooperation. Grassroots cultural exchanges, especially among Sami communities, remain vital. Sustainable tourism strategies aim to balance mass tourism in hubs like Rovaniemi with boutique experiences in other areas while adapting to warmer seasons. Developing autumn tourism or four-season offerings, such as hiking, wellness retreats, and eco-tourism, can reduce dependency on winter and stabilize the sector year-round. Expanding the bioeconomy, circular economy, and digital services further diversifies the economy, building resilience and creating opportunities beyond seasonal industries.

4.4.6.6 Challenges and Lessons Learned

Lapland faces demographic decline, labor shortages, and urban migration, straining public services and the labor force. Seasonal tourism and the decline of traditional industries exacerbate economic challenges. Infrastructure gaps, including transport hinder equitable development. Fragmented governance, dominated by small municipalities, limits coordination and innovation uptake. Poor collaboration between academia and policymakers further restricts progress. Experts call for inclusive governance, better public services, and diversified growth strategies focusing on education, environmental stewardship, and localized economic development. Circular economy practices and sustainable tourism offer promising pathways forward.

4.4.6.7 Implications for EU Cohesion Policy and Cross-Border Cooperation

Lapland demonstrates the need for a differentiated EU Cohesion Policy to address peripheral regions' unique challenges. Tailored funding for sustainable tourism, the bioeconomy, and digital innovation is critical. Enhanced governance and collaboration between academia, businesses, and policymakers can foster innovation. Supporting resilient cross-border ties requires adaptive frameworks, long-term funding, and grassroots initiatives. Improved infrastructure and capacity-building in regional ecosystems can bridge the gap between research and application. By fostering inclusive, place-based approaches, Lapland can inspire other peripheral regions navigating complex challenges.

4.4.6.8 Conclusions

Lapland offers valuable lessons on resilience in Europe's northern peripheries. The region showcases the potential of leveraging natural and cultural assets for innovative and sustainable development, despite facing demographic, economic, and geopolitical challenges. Exaptive resilience, demonstrated through bioeconomy initiatives, tourism, and Arctic technology, underlines the importance of adaptability. However, significant gaps remain in governance and infrastructure. EU Cohesion Policy can play a pivotal role by providing targeted support for sectors like sustainable tourism and innovation while addressing governance and infrastructure challenges. Cross-border cooperation must adapt to geopolitical shifts, prioritizing environmental protection and cultural exchange while fostering Nordic and EU ties.

4.5 Cross-Case Synthesis and Comparison

CROSS-CASE SYNTHESIS

Border regions face shared challenges, including peripherality, demographic decline, and dependency on traditional industries, yet they exhibit resilience through diverse strategies. Local networks and cultural assets drive community-led responses, while cross-border cooperation and EU cohesion policy support infrastructure, innovation, and capacity-building. The effectiveness of these efforts depends on local institutional capacities and adaptive governance.

Building on the detailed insights from the case studies, this section synthesizes findings to identify overarching patterns and variations in territorial (exaptive) resilience across the examined regions. While the case studies of Maramureș County in Romania, Lapland Region in Finland, Szabolcs-Szatmár-Bereg County in Hungary, Olsztyn Region in Poland, and Vilnius County in Lithuania offer distinct narratives shaped by their unique socio-economic, institutional, and geographic contexts, they also reveal shared challenges and opportunities. This synthesis moves beyond individual narratives to uncover the structural, institutional, and cultural factors that drive resilience in these border regions. By integrating these diverse experiences, this analysis aims to inform policymakers about the conditions that enable or hinder territorial exaptive resilience, emphasizing the importance of tailored and place-based strategies. Such a comparative approach offers a deeper understanding of how border regions adapt to crises, leverage their assets, and navigate external pressures to build sustainable and inclusive futures.

4.5.1 Peripheral Challenges and Opportunities

A defining feature of the five regions is their peripheral location within the EU. These regions often lie far from economic and political centers, grappling with limited accessibility, demographic challenges, and structural economic disadvantages. Peripherality shapes both vulnerabilities and resilience mechanisms, creating a duality in their developmental trajectories. In Maramureș County, decades of population decline, particularly among younger generations, have led to significant economic stagnation. Outmigration has created labor shortages and eroded social infrastructure, leaving villages struggling to maintain essential services. Similarly, the Olsztyn Region faces high rates of outmigration, compounded by geographic isolation near the militarized Kaliningrad border, which further limits economic diversification. Even in Lapland, a region often cited for its innovative approaches, the remoteness and sparse population present persistent barriers to attracting investment and talent. These challenges are mirrored in Szabolcs-Szatmár-Bereg County and Vilnius County, where demographic pressures exacerbate existing inequalities and economic vulnerabilities. At the same time, peripherality has fostered strong community ties and a degree of self-reliance. These conditions have helped local populations adapt to external shocks, drawing on traditional knowledge and informal networks. This paradox highlights the potential for leveraging peripherality as a resource for building unique, place-based resilience strategies.

4.5.2 Shifting from Traditional Industries to Emerging Opportunities

The regions share a historical dependence on traditional industries such as agriculture, forestry, and mining. These sectors have long defined local economies but are increasingly challenged by environmental changes, globalization, and shifting market dynamics. In Maramureș County, the collapse of the mining industry in the early 2000s left behind environmental degradation and economic stagnation. However, initiatives like the SPIRE project illustrate how abandoned industrial landscapes can be repurposed for renewable energy and ecological restoration, turning liabilities into assets. Similarly, Lapland has transformed its reliance on forestry into opportunities in the bioeconomy and sustainable tourism, capitalizing on its pristine Arctic environment.

Szabolcs-Szatmár-Bereg County and Olsztyn Region are navigating transitions from agriculture and food processing toward logistics, renewable energy, and cross-border trade. These shifts highlight the potential for innovation and diversification when regions actively align traditional assets with emerging economic trends.
Yet, such transitions are not without challenges. Dependence on declining industries often creates economic vulnerabilities, and successful diversification requires sustained investment, institutional support, and cross-sectoral collaboration.

4.5.3 Cross-Border Cooperation as a Double-Edged Sword

Border regions naturally lend themselves to cross-border interactions, offering opportunities for collaboration and resource sharing. However, the geopolitical contexts of these regions greatly influence the nature and effectiveness of such cooperation. Lapland has benefited from Nordic cooperation frameworks which foster partnerships in environmental protection and innovation. Similarly, Szabolcs-Szatmár-Bereg County has leveraged its cultural ties with Ukraine to respond effectively to the refugee crisis, demonstrating how long-standing transnational networks can enhance resilience during crises.
In contrast, Vilnius County and Olsztyn Region face greater challenges. Geopolitical tensions with Belarus and Russia have disrupted cross-border interactions, limiting economic exchanges and creating security risks. For these regions, geopolitical instability underscores the fragility of cross-border networks and highlights the need for adaptive governance mechanisms to navigate such complexities.

4.5.4 Vulnerability to External Shocks

The exposure of these regions to external shocks—be it economic crises, geopolitical tensions, or environmental disruptions—represents a common challenge. The impacts of such shocks, however, are mediated by each region's specific socio-economic and institutional capacities. For example, the COVID-19 pandemic had a profound impact across all regions, disrupting tourism in Lapland and Olsztyn and straining social services in Szabolcs-Szatmár-Bereg County and Vilnius County due to refugee inflows. Climate change poses a particularly acute threat to Lapland, affecting traditional industries such as reindeer herding and winter tourism. These crises reveal both the vulnerabilities of border regions and their capacities for adaptation. Local networks, institutional flexibility, and community resilience often determine the speed and effectiveness of responses to such disruptions.

4.5.5 Local Resources and Networks as Drivers of Resilience

Across all regions, the mobilization of local resources and networks emerges as a cornerstone of resilience. These regions have leveraged their cultural, social, and natural assets to create innovative solutions and foster community-driven responses. In Maramureș County, the SPIRE project exemplifies how local engagement and cross-sectoral collaboration can transform environmental challenges into opportunities for sustainable development. Similarly, grassroots networks in Szabolcs-Szatmár-Bereg County were instrumental in managing the refugee crisis, drawing on cultural and linguistic ties with Ukraine to mobilize resources and support integration efforts. These examples highlight the importance of fostering local ownership and participation in resilience strategies. However, such efforts often require external support, whether in the form of funding, technical expertise, or institutional capacity building.

4.5.6 EU Cohesion Policy as a Key Enabler

EU cohesion policy and structural funds have played a pivotal role in supporting resilience initiatives across the regions. From infrastructure projects to innovation hubs, these resources have enabled local actors to address structural challenges and explore new growth paths. In Maramureș County, EU funding supported the cleanup of contaminated sites and the development of renewable energy infrastructure. Lapland utilized smart specialization strategies, supported by EU programs, to strengthen its bioeconomy and sustainable tourism sectors. However, reliance on EU funding also highlights challenges related to bureaucratic complexity and mismatched priorities, which can limit the effectiveness of such programs.

4.6 Patterns and Implications

TERRITORIAL EXAPTIVE RESILIENCE INDEX

Building territorial exaptive resilience in border regions requires place-based strategies that leverage local assets, transformative approaches to systemic change, strengthened cross-border cooperation, empowered communities, and innovative multi-level governance frameworks. These elements, supported by a nuanced and flexible EU Cohesion Policy, can foster growth and increase competitiveness that is flexible, inclusive, and future-oriented.

Building on the comparative analysis of the five case studies this section identifies critical patterns and their implications for fostering territorial exaptive resilience in EU border regions. These findings bridge the desriptive insights with broader strategic perspectives, offering actionable lessons for regional policy and EU Cohesion Policy design. The patterns identified below underscore the need for context-sensitive, integrated, and innovative approaches that reflect the complexity of territorial challenges and opportunities.

4.6.1 Importance of Place-Based and Asset-Based Approaches

A clear and recurring pattern across the cases is the necessity of place-based and asset-based strategies tailored to the unique challenges and resources of border regions. While all five regions face shared issues—such as peripherality, economic underdevelopment, and demographic decline—they each possess distinct endogenous assets that can drive resilience if effectively leveraged. Lapland exemplifies the power of a smart specialization strategy, turning its Arctic location and expertise into economic opportunities. These efforts align local traditions, such as reindeer herding, with cutting-edge innovation in bioeconomy and circular solutions. Similarly, Maramureș County demonstrates the transformative potential of localized solutions, as seen in the SPIRE project, which turned environmental and post-industrial liabilities into renewable energy initiatives and community empowerment programs. The implication for policy is clear: **a shift from uniform, top-down policy models to differentiated, bottom-up frameworks that empower local actors to harness their unique assets**. This includes adapting EU Cohesion Policy to provide flexible funding mechanisms and fostering capacities for local experimentation and innovation. Supporting such approaches requires abandoning rigid, sectoral frameworks in favor of integrated development models that acknowledge the specific needs and potentials of each border region.

4.6.2 Centrality of Cross-Border Cooperation and Governance

Border regions inherently depend on cross-border cooperation to enhance resilience, as transnational interactions provide access to complementary resources, knowledge, and opportunities. The case studies reveal that cross-border governance is both an enabler and a limiting factor, depending on the geopolitical and institutional context. For example, Szabolcs-Szatmár-Bereg County's cultural and linguistic ties with Ukraine enabled a swift and empathetic response to the refugee crisis, creating economic and social opportunities while strengthening regional solidarity. Lapland similarly benefited from Arctic cooperation frameworks that enhanced its access to international funding and expertise. However, challenges persist. Vilnius County's securitization in response to hybrid threats from Belarus has strained its cross-border engagement, emphasizing the geopolitical risks faced by some border regions. Similarly, the Olsztyn Region's ties with the Kaliningrad Oblast have been disrupted by EU-Russia tensions, leaving the region economically isolated. The lesson here is that **cross-border cooperation requires institutional frameworks that transcend project-level initiatives, fostering long-term trust, reciprocity, and alignment of interests**. This necessitates strengthened support for European Groupings of Territorial Cooperation (EGTCs) and adaptive governance models that reflect local realities while aligning with EU-wide goals.

4.6.3 Need for Transformative Resilience

The case studies highlight a pressing need to move beyond reactive resilience focused on short-term recovery toward more exaptive and transformative approaches. True resilience involves the capacity to use crises as catalysts for systemic change, fostering new development paths that address structural vulnerabilities. Maramureş County's SPIRE project epitomizes such transformation, as it mobilizes local communities to repurpose industrial landscapes into renewable energy assets, creating new employment opportunities. In Lapland, adaptation to climate change has driven innovation in Arctic testing and bioeconomy sectors, illustrating how regions can harness external shocks to build competitive advantages. However, current resilience efforts often prioritize immediate coping mechanisms. Szabolcs-Szatmár-Bereg County's refugee response, while effective in the short term, raises questions about the long-term sustainability of its social systems. Similarly, Vilnius County's focus on border militarization risks undermining its prospects for future cross-border collaboration. The implication is that **resilience strategies must balance short-term responses with long-term aspirations for inclusivity, sustainability, and systemic change**. EU Cohesion Policy should encourage regions to integrate adaptive planning into their development strategies, leveraging crises to create pathways for transformation.

4.6.4 Potential of Social Innovation and Community Empowerment

Community-driven initiatives play a pivotal role in fostering resilience, particularly in regions with limited institutional resources. Social innovation enables regions to mobilize local networks and repurpose existing assets, often filling gaps left by formal institutions. Szabolcs-Szatmár-Bereg County's grassroots response to the refugee crisis exemplifies the strength of community-led resilience Similarly, the SPIRE project in Maramureş County highlights the potential of involving communities in co-designing solutions that are both locally relevant and scalable. How ever, challenges such as structural inequality and lack of institutional support can undermine the sustainability of community-led initiatives. In Vilnius County, polarized public discourse has hindered grassroots intercultural dialogue, while small-scale farmers in the Olsztyn Region face barriers to accessing markets and resources due to the dominance of agribusiness. EU Cohesion Policy should therefore prioritize **creating enabling environments for social innovation, offering resources, training, and platforms for experimentation**. By empowering local actors as agents of change, regions can build resilience that is both inclusive and enduring.

4.6.5 Importance of Multi-Level and Multi-Stakeholder Governance

Effective resilience-building in border regions requires alignment and collaboration across multiple governance levels and sectors. However, the case studies reveal significant disparities in the capacity to achieve such coordination. Lapland's integration into Arctic cooperation frameworks demonstrates the benefits of multi-level governance, where regional, national, and international actors collaborate to address shared challenges. In contrast, Vilnius County faces coordination challenges between local and national authorities, particularly in managing migration and security crises. The implication is that **multi-level governance arrangements must prioritize trust-building, inclusivity, and alignment across stakeholders**. This includes fostering innovative governance models such as living labs or public-private-people partnerships, which bring together diverse actors to co-create resilient solutions.

4.6.6 Conclusion

The patterns and implications identified across the five case studies provide a roadmap for fostering territorial exaptive resilience in border regions. By adopting place-based strategies, strengthening cross-border cooperation, enabling transformative resilience, empowering communities, and enhancing governance frameworks, policymakers can build resilience that is not only adaptive but transformative. These findings underline the need for a more nuanced and flexible EU Cohesion Policy, one that recognizes and supports the diversity of border regions while fostering long-term, systemic change.

5 Synthesis – What Have We Learned?

EASTERN BORDER REGION PARADOX

Despite systemic disadvantages such as peripherality and lower institutional quality, many eastern border regions exhibit exaptive resilience by creatively reallocating resources and leveraging endogenous strengths, enabling them to adapt in ways that contrast with the stability-focused resistance of central regions.

The primary aim of this study was to investigate territorial exaptive resilience, focusing on the capacity of regions to repurpose and redeploy existing assets, resources, and capabilities for new applications when faced with changing circumstances. This concept, rooted in the evolutionary biology term "exaptation" (Gould & Vrba, 1982), offers a framework for understanding how regions adapt and transform in innovative ways during crises. Exaptive resilience moves beyond the traditional notion of "bouncing back" to a pre-crisis state, emphasizing proactive and transformative adaptation to foster new growth paths (Boschma, 2015; Martin & Sunley, 2015). By integrating these insights, the study provides a future-oriented perspective on regional resilience, with an emphasis on leveraging endogenous resources to navigate transitions and challenges (Grillitsch & Sotarauta, 2020).

The relevance of territorial exaptive resilience is particularly evident in the EU's eastern border regions, which face unique challenges due to their historical, institutional, and socio-economic trajectories. These areas are often disadvantaged, peripheral, and agrarian, characterized by lower levels of economic development, innovation capacity, and institutional quality compared to their central and western counterparts (Batista et al 2024). Factors such as geographic isolation, limited economic diversification, and reliance on traditional sectors exacerbate their vulnerability to external shocks (Capello & Caragliu, 2021). These findings align with the clustering results from this study, which clearly distinguished these regions based on their socio-economic and structural characteristics, confirming their systemic disadvantages.

Despite these systemic disadvantages, the findings reveal that many eastern border regions have demonstrated remarkable exaptive resilience. By reallocating and restructuring their resources and capabilities, they have creatively responded to crises and disruptions. The Territorial Exaptive Resilience index highlights that, in contrast to central regions—where resistance (maintaining economic stability) is predominant—eastern border regions often thrive by adopting exaptive strategies. These regions leverage their endogenous resources in innovative ways to forge potential new opportunities.

This pattern, which we call the "Eastern Border Region Paradox", draws an analogy to the "Singapore paradox" (Briguglio et al., 2009; Miskolczi 2020). The Singapore paradox suggests that small, open, and vulnerable economies can build resilience through a combination of economic diversification, human capital development, and institutional quality. Similarly, the eastern border region paradox aligns with the growing evidence of successful economic development and resilience-building in several countries and regions in the area, such as Poland, Estonia, Lithuania, Finland, and Romania (Győrffy 2022). These cases demonstrate the potential of peripheral and lagging regions to break out of the "middle-income trap" and achieve smart, sustainable, and inclusive growth through place-based strategies that build on their unique strengths and potentials.

5.1 Key Drivers of Exaptive Resilience

KEY DRIVERS OF EXAPTIVE RESILIENCE

Exaptive resilience is driven by three critical dimensions: the mobilization of local actors and networks, supportive institutional frameworks, and investments in skills, capacities, and infrastructure. These factors enable regions to repurpose resources, foster innovation, and adapt to crises.

To identify the factors driving exaptive resilience, the study employed a mixed-methods approach, combining quantitative analysis with qualitative case studies. The econometric analysis revealed that higher institutional quality, knowledge-intensive sectors, and local resilience factors positively influence the ability of regions to withstand and recover from shocks (Cortinovis et al., 2017; Crescenzi & Giua, 2020, Miskolczi 2020). For exaptive regions, traditional sectors such as agriculture and industry also emerge as significant contributors. This finding suggests that innovation within these sectors can be pivotal for peripheral regions to diversify and adapt. The study further highlights the importance of EU funds, which have provided critical support for structural transformation in border regions, particularly by enhancing infrastructure and fostering economic diversification.

The qualitative component of the study offers a deeper understanding of how exaptive resilience manifests in practice. Each region's response to crises illustrates the dynamic interplay between local resources, institutional frameworks, and socio-economic strategies. In **Maramureş**, the SPIRE project exemplifies how environmental challenges linked to mining were converted into opportunities through phytoremediation. This initiative not only addressed pollution but also revitalized the community, empowering residents to reimagine their region's economic potential. Similarly, **Lapland** leveraged its pristine environment and traditional knowledge to expand nature-based tourism and bioeconomy initiatives, creating sustainable economic diversification while capitalizing on its unique assets. The case of **Szabolcs-Szatmár-Bereg** illustrates the role of social capital in resilience-building. The region mobilized local networks and civil society organizations to provide emergency assistance to Ukrainian refugees, strengthening its social cohesion and capacity for collective action. **Olsztyn** and **Vilnius** highlight the importance of institutional coordination and skills development. Olsztyn's potential for sustainable agriculture is constrained by structural barriers, but targeted investments in inclusive rural development could unlock its latent potential. In Vilnius, effective policy coordination was instrumental in managing the challenges posed by refugee crises and geopolitical tensions.

The convergence of quantitative and qualitative findings reinforces the robustness of the three overarching dimensions of exaptive resilience: mobilization of local actors and networks, supportive institutional frameworks, and investments in skills, capacities, and infrastructures. These dimensions emerged consistently across both methodological approaches, offering a coherent framework for understanding and fostering resilience.Quantitative analyses underscore the significance of these dimensions by identifying key drivers of resilience. Higher institutional quality, the presence of knowledge-intensive sectors, and local resilience factors were found to positively influence regions' ability to adapt and recover. These findings align with the qualitative insights, where institutional frameworks and investments in human and physical capital repeatedly surfaced as critical enablers. For example, the econometric results highlighted the role of institutional quality in shaping adaptive capacities, resonating with the qualitative evidence from Vilnius, where coordinated policies facilitated effective crisis management.

Similarly, the mobilization of local actors, captured in the qualitative data, complements quantitative observations about the importance of social cohesion and community-level resilience. The case studies of Maramureş and Szabolcs-Szatmár-Bereg illustrate how local engagement and grassroots

efforts can repurpose existing resources, while the quantitative data suggest that social capital and local governance are instrumental in translating these efforts into measurable outcomes.

Investments in skills, capacities, and infrastructures also link the two approaches. The econometric findings point to the importance of economic diversification and knowledge-intensive industries, which require substantial investments in human capital and innovation. This aligns with the qualitative insights from Lapland and Olsztyn, where strategic investments in education, infrastructure, and sectoral innovation were identified as pathways to unlocking resilience potential.

5.2 Adaptability and Exaptibility: A Theoretical Conclusion

BALANCING ADAPTABILITY AND EXAPTIBILITY

Regional growth depends on balancing adaptability, which fosters stability through structural investments like institutional quality and economic diversification, with exaptibility, which drives transformation by leveraging local networks, social capital, and flexible policies for innovation and new opportunities.

The findings of this study highlight the interconnected roles of adaptability and exaptibility in shaping territorial resilience. These concepts, introduced earlier in the study, provide a nuanced framework for understanding the mechanisms through which regions navigate crises and capitalize on opportunities for transformation. While **adaptability** refers to the capacity for incremental adjustments within an existing development trajectory, **exaptibility** emphasizes the ability to repurpose and recombine resources to create entirely new pathways for growth and resilience. The distinction between these capacities provides a valuable lens for interpreting the study's findings. **Adaptability** reflects the structural conditions that enable regions to respond to shocks by enhancing their existing systems, such as improving institutional quality, diversifying their economies, and investing in foundational infrastructures. This aligns with the econometric results, which identify institutional quality and economic diversification as critical drivers of resilience. For example, regions with robust institutional frameworks, as seen in Vilnius, demonstrated greater capacity to coordinate responses to complex crises, such as the refugee influx. In contrast, **exaptibility** highlights the capacity that allow regions to leverage crises as opportunities for transformation. This capacity is closely tied to fluid factors such as local networks, social capital, and flexible policy environments, which enable experimentation and innovation. The case studies vividly illustrate exaptive processes: Maramureș transformed environmental liabilities into sustainable opportunities, and Szabolcs-Szatmár-Bereg leveraged social cohesion and grassroots mobilization to provide critical support during the refugee crisis while fostering resilience and community solidarity.

The interplay between adaptability and exaptibility is essential for understanding the multidimensional nature of resilience and growth. While resilience itself represents only the potential for transformation, it is through the dynamic interaction of adaptability and exaptibility that this potential can materialize into actual structural change. Exaptive resilience is about the latent capacity for regions to repurpose and recombine their existing assets and capabilities in novel ways when confronted with crises. It opens up the possibility space for change, creating opportunities for regions to break from their established trajectories and chart new courses for growth and development.

However, the mere presence of exaptive resilience does not guarantee that these possibilities will be realized. Rather, it is the cultivation of adaptability and exaptibility that shapes whether and how regions actually navigate these possibilities and translate them into concrete outcomes. Adaptability provides the necessary stability and flexibility for regions to incrementally adjust and improve their existing systems, while exaptibility represents the proactive and future-oriented cultivation of the

enabling conditions and capacities that allow regions to fundamentally reinvent themselves when faced with disruption.

The degree to which regions can leverage their exaptive resilience to forge new development pathways, then, is a function of the strength and interplay of their adaptability and exaptibility. In line with this, the study's findings suggest that regions must balance structural stability with creative dynamism to achieve sustainable and inclusive development. Structural investments, such as improving institutional quality and economic diversification, lay the groundwork for adaptability. At the same time, fostering exaptibility requires targeted efforts to build social capital, engage local actors, and create policy environments that encourage experimentation.For instance, the econometric evidence underscores how institutional quality enhances both resistance and exaptive resilience. High-quality institutions provide the predictability and support needed for incremental improvements, while also enabling the experimentation necessary for transformative change. Similarly, the qualitative insights show how mobilizing local networks bridges these capacities, as grassroots initiatives often combine adaptive responses with innovative strategies.

To fully realize the potential of exaptive resilience, regions must develop policies and strategies that integrate adaptability and exaptibility.

The following framework synthesizes the key dimensions identified in this study:

1. **Structural Factors for Adaptability:**
    - High-quality institutions to provide stability and governance
    - Economic diversification and related variety to reduce dependency on narrow sectors.
    - Investments in transport and digital infrastructures to enhance regional connectivity and accessibility.
2. **Dynamic Factors for Exaptibility:**
    - Strengthening local networks and social capital to enable collective action and innovative solutions
    - Encouraging institutional entrepreneurship and leadership to challenge status quos and drive transformation.
    - Designing flexible and responsive policy frameworks that support experimentation and adaptive governance.
3. **Integrated Strategies:**
    - Combining structural investments with initiatives that empower local actors and foster creativity.
    - Aligning regional development policies with long-term resilience goals, emphasizing inclusivity and sustainability.

By embedding these principles into regional development strategies, policymakers can foster both adaptability and exaptibility, creating the conditions necessary to transform resilience potential into actual structural change and and enhanced regional competitiveness. This integrated approach is particularly relevant for peripheral and disadvantaged regions, where structural challenges necessitate adaptability, while opportunities for transformation hinge on exaptive processes.

6 Conclusion: From The Art of Shipwrecking to Repurposing Design

This study has explored the exaptive resilience of the EU's eastern border regions, highlighting both their vulnerabilities and their potential for transformation. These regions face significant challenges, including peripheral locations, agrarian economies, and institutional weaknesses, which heighten their exposure to economic shocks and geopolitical tensions. Yet, they have also demonstrated an impressive capacity to adapt, innovate, and repurpose their existing resources to create new opportunities in times of crisis. Building resilient and sustainable border regions requires a shift in perspective and approach. Place-based, inclusive, and transformative strategies that empower local communities and foster cross-border cooperation are essential. EU cohesion policy has a crucial role to play in this transformation by providing the flexible resources, institutional support, and incentives needed to unlock the potential of these regions and and strengthen their contribution to EU competitiveness..

Exaptive resilience can be seen as the art of shipwrecking - the ability to navigate crises and disruptions by repurposing the available resources and capabilities in creative and innovative ways. Just like a shipwrecked sailor who uses the debris and their own ingenuity to reach the shore, border regions can leverage their endogenous assets and capabilities to find new development opportunities in times of adversity. However, to build thriving and sustainable regional economies, it is not enough to simply reach the shore - it is also necessary to create the conditions that transform survival into long-term development and growth.

7 Limitations and Further Research

This study provides valuable insights into territorial exaptive resilience in EU eastern border regions, but several limitations and opportunities for future research should be acknowledged.

A key limitation concerns the differential response patterns of regions to various types of crises. While our analysis revealed that regions respond distinctly to different shocks, a more detailed examination of the relationship between specific crisis characteristics and regional responses is needed. Future research should develop a more nuanced typology of crises and systematically analyze how regions with different qualitative characteristics respond to each type. This could help identify which regional attributes are most relevant for building resilience against specific types of challenges.

The case study selection represents another limitation, as only one region per country was examined in depth. This approach, while providing rich contextual insights, may not capture the full range of intra-country variations in border region responses. Future research should investigate multiple regions within the same country to better understand how national institutional frameworks interact with local conditions to shape resilience outcomes. This could reveal important variations in how regions within the same institutional context leverage different assets and capabilities to build resilience.

The temporal scope of the analysis presents another constraint, particularly regarding the 2021-2023 period. The ongoing nature of the Russian-Ukrainian conflict means that our findings for this period are preliminary and may evolve as the situation develops. Longitudinal studies tracking how regional responses evolve over the complete crisis cycle would provide valuable insights into the dynamics of exaptive resilience over time.

A significant methodological challenge lies in the quantification of non-economic aspects of exaptive resilience. While our study incorporated qualitative assessments of social, institutional, and cultural dimensions, developing robust quantitative indicators for these factors remains difficult. Future research should focus on developing and validating new metrics that can capture these less tangible but crucial aspects of resilience.

Addressing these limitations and pursuing these research directions would significantly advance our understanding of territorial exaptive resilience and its role in regional development. This knowledge would be valuable for policymakers seeking to design more effective interventions to support border regions in navigating future challenges and opportunities.

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