From Patterns to Processes: Regional Resilience in Europe in an Era of Uncertainty

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Abstract: The contemporary era of "polycrisis" necessitates a reflection on how regional resilience is conceptualized and measured. This is a pilot study that proposes a mixed-methods explanatory sequential design that aims to capture both resilience as capacity and performance. First, employing a composite index approach, the quantitative phase evaluates regional capacity across four pillars – social, economic, environment & infrastructure, and institutional – using 17 indicators in total. This is paired with a performance analysis measured through three metrics: coping, bounce back, and bounce forward. The result is a 2x2 matrix that pits capacity against performance, categorizing regions into four quadrants. This framework is applied to 10 NUTS2 regions across Europe, selected for their near-full data availability and diversity. Initial findings test the two-stage index and the 2x2 categorization. This pilot serves as a foundational step for a future comprehensive study of all European NUTS2 regions.

Keywords*:* regional resilience, resilience capacity, resilience performance, NUTS2 regions

1. Introduction[2]

The 21st century has been marked by an unprecedented series of global crises, ranging from slow-burning challenges like climate change and demographic shifts to sudden shocks such as financial meltdowns, pandemics, and geopolitical conflicts. These events, while diverse in nature, share a common characteristic: their capacity to ripple across borders and systems, often producing far-reaching consequences. In today's complex and highly interconnected globalized world, a localized disruption – such as a flood in one country – can cascade through supply chains and financial networks, resulting in tangible economic impacts, such as a measurable reduction in GDP growth in a country on the other side of the globe. Against this backdrop, a critical and enduring question emerges: what enables societies to effectively absorb, adapt to, and recover from such multifaceted crises? In other words: to remain *resilient*.

In this picture, regions have been caught – literally and figuratively – in the middle. Regions, understood as subnational, thereby *meso-level* entities, came to the forefront of academic interest as spatially coherent engines of economic development. As globalism intensified, traditional national borders became increasingly blurry, no longer functioning as the definitive containers of socio-economic life. Consequently, we see metropolitan regions that span across borders, where the pressures of a globalized economy and the simultaneous breaking up of local communities have fundamentally reshaped our understanding regarding space and territory.

EU policy thinking has also started to put focus on what is called "territorial cohesion". Cohesion policy, traditionally being one of the most important fields of EU priorities and action, puts subnational entities first,

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aiming to reduce territorial disparities. The *Nomenclature of territorial units for statistics* (abbreviated as NUTS) was directly created in the 1970's to map and operationalize member-state's territory for targeted regional policies. It is split up into three levels[3], NUTS1 for *major socio-economic regions*, NUTS2 for *basic regions*, and NUTS3 for *small regions*. This present inquiry focuses on the NUTS2 level, consequently, the word region mostly refers specifically to NUTS2 regions (outside theoretical discussions in Section 2).

In this paper, we investigate regional resilience – a concept that encompasses a region's capacity not only to withstand immediate disruptions but also to adapt and transform in the face of persistent and evolving risks (Martin – Sunley 2015). The core of our proposed framework revolves around a dual track approach: the concept of resilience approached both as a latent *capacity* and as realized *performance*. The conceptual and methodological propositions presented in this paper should be viewed as a synthesis of existing capacity-vulnerability frameworks (Heriaud et al. 2025) and performance-based studies (Benczúr et al. 2020), aiming to bridge the gap between a region's inherent potential and its actual response to disruption.

The paper is structured as follows: first, we explore the concept of regional resilience through a literature review, highlighting current measurement approaches, focusing primarily on the conceptually and methodologically fruitful research conducted by the European Commission's Joint Research Center.[4] We then detail the first part of this research: a pilot study designed as a first meaningful step toward a large-scale empirical analysis of regional resilience across Europe. In this phase, we test our refined framework on ten selected NUTS 2 regions to evaluate its performance. Finally, we investigate the resulting data to identify the advantages and limitations of this approach, concluding with a discussion on room for improvement and directions for future research.

2. Regional resilience defined

Regions are dense networks of heterogeneous actors – including small, medium, and large enterprises, local, state and national governments, NGOs, and citizenry, along various other formations of political advocacy groups. These actors are in constant interaction, and from these local-level relationships, emergent systemic properties arise, such as a specific regional identity. These properties cannot be reduced to the characteristics of individual actors; thus, the system as a whole is always more than the sum of its parts.

A recurring theme in resilience scholarship is the acknowledged absence of a universally accepted definition and framework of the concept (Koliou et al. 2018). In our view, rather than signaling a lack of scholarly interest, definitional ambiguity represents a rapid expansion of frameworks and shifting understanding of the nature of crises and what it takes to weather them. As the nature and scale of disruptive events evolve, so too must the analytical frameworks deployed to understand the capacity of systems to withstand them. In what follows, the present section situates the concept of regional resilience within its broader contemporary context, before proceeding to discuss its principal theoretical dimensions.

[3] Additionally, a NUTS0 level is sometimes used to denote countries.
[4] The European Commission's Joint Research Center will be abbreviated as JRC both in citations and in text on all but this occasion.

The contemporary relevance of resilience thinking is underscored by the condition of *polycrisis*, a term that has gained considerable traction in both policy and academic discourse to describe the simultaneous occurrence and mutual reinforcement of crises across multiple domains (Tooze, 2022). This phenomenon has also been referred to as *converging crises* (George, 2010), *compound events / crisis* (Zscheischler et al. 2018) or *permacrisis* (Brown – El-Erian – Spence, 2023) in the academic and expert discourse around the subject. Financial instability, public health emergencies, armed conflicts, energy shocks, and the escalating consequences of climate change no longer appear as isolated events but increasingly as interconnected disturbances whose compound effects exceed the sum of their individual impacts. In such an environment, regions and other entities cannot afford to treat resilience as preparedness against a single, well-defined type of shock, instead, they must develop capacities that are robust across a spectrum of concurrent and cascading disruptions (see Folke et al. 2010 for the conceptualization of *resilience thinking*).

Simultaneously, the forces of globalization have profoundly reshaped the spatial organization of economic and social life. Major metropolitan centres have consolidated their dominance, functioning as nodes of capital accumulation and innovation, and in many cases extending their influence into polycentric urban corridors. In the European context, metropolitan regions such as the Rhine-Ruhr area, the Randstad, and the Vlaamse Ruit exemplify this tendency, as does the Northeast megalopolis in the United States. These multi-city corridors concentrate material and immaterial resources, as well as institutional capacity. This spatial concentration simultaneously sharpens the contrast between urban and rural areas, producing a growing divergence in economic opportunity, public service provision, and demographic trajectories. Peripheral and rural regions face depopulation, brain drain, and "*institutional thinness*", while metropolitan cores contend with congestion, inequality, and the social strains of rapid growth (OECD, 2023; Kovanen – Ulrich – Gailing, 2023). The resilience of any given region is therefore inseparable from its position within these broader spatial hierarchies and the relational dynamics that govern center – periphery interactions.

It is within this context that the regional scale of analysis acquires particular significance. Regional governance operates at a meso-level that is analytically advantageous: it is sufficiently proximate to local conditions to capture the particularities of place-based responses, while remaining broad enough to permit meaningful comparison and cautious generalization. Regions, understood as complex adaptive systems, constitute arenas in which national policy frameworks interact with local institutional configurations, producing outcomes that are neither fully determined by macro-level forces nor entirely reducible to micro-level agency. The study of resilience at this level therefore occupies a productive middle ground, one that enables researchers to trace the mechanisms through which structural preconditions and governance practices jointly shape the capacity to absorb, adapt to, and recover from shocks.

A central and longstanding tension within resilience theory concerns the distinction between *bouncing back* and *bouncing forward* (Manca et al. 2017). The former, rooted in the engineering conception of resilience, foregrounds the system's ability to return to its pre-shock equilibrium as swiftly as possible. This interpretation, while intuitively appealing, has been criticized for its implicitly conservative orientation: it presupposes that the pre-crisis state was desirable and that restoration is the appropriate goal (MacKinnon – Derickson, 2012). By contrast, the evolutionary and adaptive perspective emphasizes the capacity for transformation, arguing that

genuinely resilient systems are those that can leverage a crisis as an opportunity to reorganize along more sustainable and equitable development trajectories (Martin – Sunley, 2015).

These temporal dynamics are systematically captured in the *life cycle model of resilience* proposed by the JRC (Pontarollo – Serpieri, 2018 based upon the work of Vernon, 1966 regarding product life cycles in business management). The model posits that regions, much like organisms or even industries, move through successive phases: *introduction*, *growth*, *maturity*, and ultimately either *decline* or *renewal*. This cyclical framing embeds the concept of resilience within a longer time horizon.

In their highly influential work, Martin and Sunley (2015) operationalized regional economic resilience along four closely interrelated but analytically distinct dimensions. The first dimension, *resistance*, captures the magnitude of the shock's immediate impact – the vulnerability of the system. The second dimension, *recovery*, concerns the speed and extent of the return. The third dimension, *re-orientation*, asks whether the region is capable of transforming its economic structure and institutional arrangements as a consequence of the crisis – for example, whether a declining industrial district (a so called "*rust area*") can successfully transition to a diversified structure. In the fourth, last dimension, just as in the previously described life cycle model, either *renewal* or *decline* occurs.

The JRC has done extensive work on regional resilience. Their foundational 2017 study (Manca et al. 2017) conceptualizes regional resilience within a new framework that goes beyond traditional economic approaches. The authors argue that purely macroeconomic indicators, such as GDP growth or employment rates, are unable to fully describe a society's capacity to withstand crises; therefore, they build the concept of resilience around the capacity for the sustainable production of social well-being. In this interpretation, resilience does not merely mean "bouncing back" after a shock but rather the society's ability to preserve and generate well-being in the face of shocks and persistent structural changes, doing so without compromising the living standards of future generations.

The conceptual core of the study is the so-called "system view," which models society as a complex production process. This system is structured into three main pillars: assets, the engine, and outcomes. The assets pillar includes human, social, natural, and built capital, which serve as the system's inputs. The engine represents the social fabric and institutional infrastructure – including markets, communities, and political mechanisms – whose task is to transform these assets into well-being. Finally, the outcomes pillar represents actual social and economic well-being, encompassing both material indicators (such as income) and immaterial aspects, such as life satisfaction or health status.

Another cornerstone of the conceptualization is the time dimension and the dynamics of response reactions. The authors identify three distinct but interrelated resilience phases: *absorption*, *adaptation*, and *transformation*. Absorption is the system's ability to cushion the direct impacts of a shock in the short term; adaptation reflects the medium-term flexibility with which society adjusts to changed circumstances; and transformation denotes the long-term capacity through which a region can fundamentally renew itself and embark on a new, more favorable development path – that is, to bounce forward.

The approach places emphasis on the distinction between subjective and objective indicators. A key insight of the study is that economic regeneration (e.g., GDP growth) often does not coincide with the recovery of social trust or individual well-being. Therefore, the conceptual model integrates individuals' perceptions and expectations, as these fundamentally influence social behavior and, consequently, the stability of the system as a whole. Overall,

the JRC model defines resilience not as a state but as a multifaceted process, where a region's success is measured by the quality of interactions between system elements and the sustainable provision of well-being.

3. Measurement approaches

As the theoretical popularity of resilience has grown, the difficulties of operationalization and measurement have become increasingly apparent. Regarding measurement, a dual exposure (or dual demand) can be identified, naturally driven by partially differing motivations:

(1) On one hand, there is significant practical interest in using resilience metrics to support decision-making. Following practical considerations, this approach demands measurement results that are as simple and intuitive as possible – ideally reduced to a single score – based on directly observable phenomena (hard data) within an automatable process.

(2) On the other hand, the scientific community approaches the issue with the aim of capturing the phenomenon's full complexity. From this perspective, high-level aggregation is seen as inconsistent with theoretical considerations, and it is deemed desirable to weigh subjective aspects and utilize qualitative procedures as well. It is within this dual context that we must approach the problems of operationalization.

From the perspective of operationalization, it is important to reiterate that we view resilience as a complex and latent phenomenon: it cannot be observed directly but can only be grasped through its constituent parts, and most often through diverse measurement tools. We face a fork in the road: some measurements are aggregated at a high level to provide composite values, while others, in order to avoid the information loss resulting from aggregation, renounce the demand for reduction and opt for a "raw" presentation of indicators through a "dashboard" – a solution that includes displaying all values simultaneously (see the *Regional Resilience Dashboard for the EU*: Heriaud – Jossens – Le Blanc, 2025, abbreviated as: *RRDB*). Consequently, dashboards are capable of presenting a complex picture, but they cannot be used as comparative tools, or only with great difficulty.

There are horizontal multidimensional approaches to measuring resilience as well. The "BRIC", Baseline Resilience Indicators for Communities (Cutter et al. 2010) is perhaps the most well known in this school of measurement: this framework operationalizes resilience along a diverse set of six "capitals", that is social, economic, community, institutional, infrastructural and environmental resilience. Although the BRIC framework was originally designed to capture community resilience of counties in the United States, it has been widely adapted to different settings and levels of measurement as well (see Camacho et al. 2023; Csizovszky - Buzási, 2023; Milenković et al. 2026). Nevertheless, the BRIC framework is grounded in the DROP (*Disaster Resilience of Place*, developed by Cutter et al. 2008) theoretization of resilience, primarily focusing on disaster resilience in principle, but also employing a wide array of indicators, pushing BRIC toward a universal approach to resilience. This multidimensionality of what is, in essence, a resilience capacity framework has proved to be fruitful both conceptually and methodologically.

Inspiration was also drawn in the development of our framework from the work done by Briguglio et al. (2009). The authors aimed to capture inherent economic vulnerability and policy-driven nurtured resilience of countries, using the "*Singapore Paradox*" as their starting example: an economy that is highly vulnerable to exogenous

shocks, yet it achieved enviable macroeconomic performance (Briguglio et al. 2009: 230 – 231). The authors constructed a resilience index, and building upon previous conceptualization (Briguglio, 2004) categorized cases in a 2x2 matrix, the four categories being: *best case, worst case, self-made*, and *prodigal son*. For a study that aims to incorporate quantitative and qualitative elements, we see this approach particularly advantageous – it creates an opportunity to use a composite index not in isolation, but as an initial phase setting up the stage for a qualitative "deep dive" part based upon the 2x2 categorization.

4. Capacity x Performance framework: a pilot study

The preceding sections have established that regional resilience is a theoretically contested, multidimensional, and inherently latent phenomenon, the measurement of which poses considerable methodological challenges. The present section outlines the design rationale for a pilot study that seeks to address these challenges. The overarching purpose of this study is to begin with a quantitative empirical analysis capable of identifying patterns in regional resilience performance across European NUTS2 regions, which subsequently serves as the foundation for a more thorough future qualitative investigation in the form of comparative case studies. This logic follows the mixed methods explanatory sequential design, in which an initial quantitative phase generates findings that are then explored, contextualized, and explained through subsequent qualitative analysis – the latter not being part of this present paper. The rationale for this sequencing is straightforward: quantitative indices can reveal *what* happened and *where*, but they cannot, on their own, illuminate *why* certain regions navigated a crisis more effectively than others. By grounding the qualitative phase in empirically derived patterns, the design ensures that case selection and analytical focus are driven by evidence rather than by theoretical presupposition alone.

Turning to the quantitative component, it must be acknowledged that the landscape of resilience measurement is characterized by a proliferation of metrics, indices, and indicator sets that, while often building upon one another, have yet to converge upon a commonly accepted standard. Successive studies have proposed composite indices with varying selections of indicators, weighting schemes, and aggregation methods, each reflecting particular theoretical commitments and data availability constraints.

Overall, we call for a pragmatic strategy: after a thorough look at resilience literature, we should synthesize a framework that brings "the best of both worlds" together, namely it incorporates the horizontal multidimensionality of resilience, is able to accommodate quantitative and qualitative elements in a coherent structural flow, while also remaining flexible and easily reproducible. In the following, we elaborate on these aims step by step.

The first aim of the study: to adjust the analytical framework to the post-coronavirus context. The Covid-19 pandemic constituted a shock of a fundamentally different character than the 2008 financial crisis, affecting not only economic output but also public health systems, social cohesion, institutional trust, and environmental conditions simultaneously. Moreover, the pandemic did not arrive in isolation, it unfolded in the context of what has been termed *polycrisis* (see section 2 for theoretical implications). A study of resilience designed primarily to capture the effects of a financial downturn cannot be expected to perform adequately when the disruption in question simultaneously destabilizes labour markets, overwhelms healthcare infrastructure, disrupts education,

and erodes social trust. The framework must therefore be reconceptualized to reflect this broader and more compound threat environment, while avoiding crisis-specific "siloing".

The second aim follows directly from this recognition: to apply a generalized, multidimensional approach to resilience measurement that explicitly moves beyond economic indicators. If the nature of contemporary crises is multi-domain, then the measurement of a region's capacity to withstand and recover from such crises must be multidimensional (see Folke et al. 2010 and Carpenter et al. 2012 regarding generalized conceptions of resilience). An exclusive reliance on macroeconomic variables – GDP growth, employment rates, or trade balances – risks producing a truncated picture that conflates economic recovery with genuine societal resilience. The pilot study therefore adopts a "*beyond economic*" orientation, incorporating social, environmental, and institutional dimensions alongside economic indicators to construct a more comprehensive and theoretically grounded assessment of regional resilience capacities and performance.

Third: the study adopts a horizontal multidimensional approach organized around four thematic pillars – social, economic, environment & infrastructure, and institutional – rather than a framework structured along the axes of capacities versus vulnerabilities (see the RRDB methodology), or one organized by resilience functions and systemic elements such as *assets*, *engines*, and *outcomes* (see the previous JRC study: Benczúr et al. 2020). We readily acknowledge that frameworks grounded in the capacities – vulnerabilities distinction, as well as those disaggregating resilience into systemic elements, are conceptually sophisticated and yield considerable insight into resilience capabilities and performance in their own right. Their analytical power lies precisely in their ability to trace the internal dynamics of resilience processes and to differentiate between inputs, mechanisms, and results within a single integrated model. However, for the specific purposes of the present study – which is designed as the first phase of a mixed methods explanatory sequential analysis – a horizontally structured, multidimensional approach offers distinct practical and methodological advantages, already established in the beginning of this section.

The architecture of the pilot study rests on a structural separation between two complementary but conceptually distinct objects: resilience *capacity* and resilience *performance*. Although this distinction is implicit in much of the resilience literature, it is rarely operationalized as an explicit two-stage empirical design. The present study makes this capacity vs. performance separation the organizing principle of the quantitative framework. Theoretically, the capacity of a region to withstand shocks is a structural property that exists prior to any particular crisis. It is constituted by the socio-economic endowments and institutional configurations that are in place when a disruption arrives. Performance is an observed outcome: it shows us how a region actually traverses a specific crisis episode and can only be assessed retrospectively, through indicators that exhibit genuine crisis-induced variation. The two are related but not identical: a region may possess strong structural capacities yet perform poorly due to governance failures or particular crisis effects.

4.1 Pillars

Our first index (find the methodological details in Section 4.2 – Stage 1 CRRCI description) is organized around four pillars – social, economic, environment and infrastructure, and institutional – each capturing a distinct but interrelated domain of regional resilience *capacity*. This arrangement constitutes the "*beyond economic*" approach

articulated above, by extending measurement into green, social and institutional dimensions, thereby capturing a much more comprehensive picture. The indicators selected for each pillar are drawn primarily from Eurostat's regional database at the NUTS2 level, supplemented by the European Quality of Government Index (commonly referred to as *EQI* in literature and in the rest of this paper) and the JRC's EDGAR[5] emissions database, and satisfy three minimum criteria: NUTS2-level availability and sufficient time-window coverage for EU regions, and a clear theoretical link to resilience capacity. The individual indicators, their data sources, and availability are summarized in Table 1.

The ***social pillar*** consists of five indicators that collectively capture a region's human capital base. It includes measures of educational disengagement (early school leaving, NEET rates), poverty risk, tertiary education attainment, and the old-age dependency ratio. The underlying logic behind this pillar is that regions with deeper human capital reserves, lower social vulnerability, and more favourable demographic structures enter a crisis with greater absorptive capacity and a broader base for post-crisis adaptation, resulting in less overall crisis vulnerability in the social dimension.

The ***economic pillar*** consists of six indicators designed to capture regional economic capacity. It encompasses measures of aggregate output and household-level material well-being, the innovation ecosystem (R&D expenditure and high-tech employment[6]), economic diversification[7], and the employment rate. The pillar is deliberately structured to reflect not only how large a regional economy is, but how it is structured: a region with high GDP but concentrated in a single sector should be considered overall worse endowed in terms of capacity than one with moderate output distributed across a diversified economic base (Boschma 2016).

The ***environment and infrastructure pillar*** represents a deliberate expansion and shift of our framework, to allow for the inclusion of a green dimension into operationalization. The pillar merges environmental quality measures (air pollution mortality, greenhouse gas intensity) with digital infrastructure (broadband access), capturing both the ecological conditions and the digital-connectivity endowments that jointly shape structural resilience. The inclusion of a green dimension reflects the growing recognition – embedded in EU policy thinking, particularly in the European Green Deal (see European Commission, 2020) and the EU's Recovery and Resilience Facility (see European Commission, 2021) in the wake of the coronavirus pandemic – that carbon-intensive regional economies (for example the Rhine-Ruhr in Germany) face not only environmental risks but also significant transition risks as decarbonization policies accelerate (see Vandeplas et al. 2022, particularly about what the authors call "*brown jobs*" and "*brown activities*", pp. 15-16.). On the other hand, digital connectivity proved decisive during the Covid-19 pandemic for private and public services' continuity, and for educational access – therefore, the inclusion of a digital part in this pillar is conceptually necessary.

[5] EDGAR is short for *Emissions Database for Global Atmospheric Research*. Find more information here: https://edgar.jrc.ec.europa.eu/

[6] The Eurostat dataset for employment in high-technology sectors (htec_emp_reg2) reports employment figures in thousands. For meaningful cross-regional comparison, these figures are divided by total employment, expressed as share of total employment.

[7] Economic diversification is operationalized as the Herfindahl-Hirschman Index (HHI), that is computed from the sectoral composition of gross value added. Higher HHI values indicate greater sectoral concentration, the indicator is therefore inverted prior to normalization so that higher values reflect greater diversification.

The ***institutional pillar*** draws on all three dimensions of the European Quality of Government Index[8] (EQI: Charron – Lapuente – Bauhr, 2024):[9] citizens' assessment of public service quality, experiences of corruption, and the perceived impartiality of public institutions. Governance quality is regularly recognized as a critical mediating variable in regional resilience: it shapes the effectiveness of crisis response, the legitimacy of emergency measures (Rios – Gianmonea, 2020).

Pillar	Indicator & (Eurostat / EQI) source code	Data availability
Social	Early leavers from education and training (edat_lfse_16)	2000 – present, all NUTS2 regions
	NEET rate (15–29, not in employment, education or training) (edat_lfse_22)	2000 – present, all NUTS2 regions
	Persons at risk of poverty or social exclusion (ilc_peps11n)	2014 – present, almost all NUTS2 regions
	Population with tertiary education (25–64) (edat_lfse_04)	2000–present, all NUTS2 regions
	Old-age dependency ratio (demo_r_pjanind2)	1990–present, all NUTS2 regions
Economic	GDP per capita in PPS (nama_10r_2gdp)	2000 – present, all NUTS2 regions
	Net disposable household income (nama_10r_2hhinc)	2000 – present, all NUTS2 regions
	R&D expenditure (GERD as % of GDP) (rd_e_gerdreg)	2000 – present, almost all NUTS2 regions
	Employment in high-tech and knowledge-intensive sectors (htec_emp_reg2)	2008 – present, all NUTS2 regions
	Economic diversification (Herfindahl-Hirschman Index of sectoral GVA) (derived from nama_10r_3gva)	2000 – present, all NUTS2 regions
	Employment rate (20 – 64) (lfst_r_lfe2emprt)	2000 – present, all NUTS2 regions
Environment & Infrastructure	Premature deaths due to exposure to fine particulate matter (PM2.5)	2005 – 2023, all NUTS2 regions
	GHG emissions per capita (total, by sector)	1990 – 2023, all NUTS2 regions
	Households with broadband access	2006 – present, almost all NUTS2 regions
Institutional	Quality of Government (EQI) – Corruption	5 waves (2010, 2013, 2017, 2021, 2024), almost all NUTS2 regions covered (Germany, Belgium excluded)
	Quality of Government (EQI) – Impartiality	5 waves (2010, 2013,

[8] We incorporated EQI deconstructed in its constituent three indicators to allow for future modifications and „tinkering" (possibly expansions as well) to the institutional pillar.

[9] The European Quality of Government Index is available for five survey waves – 2010, 2013, 2017, 2021, and 2024. We assume that perceived governance quality is sufficiently stable over a short (in this case, three-year) horizon to justify treating a single survey wave as representative of the period between waves. No interpolation between waves is performed, the 2017 datapoints are used for the 2019 benchmark year.

		2017, 2021, 2024), almost all NUTS2 regions covered (Germany, Belgium excluded)
	Quality of Government (EQI) – Quality of services	5 waves (2010, 2013, 2017, 2021, 2024), almost all NUTS2 regions covered (Germany, Belgium excluded)

All indicators are normalized using min-max rescaling to the 0 to 1 interval. A normalized score of 1 corresponds to the best-performing region on that indicator and 0 to the worst. To ensure a uniform interpretation, all indicators for which higher values denote worse outcomes are inverted prior to normalization.

4.2 Stage 1: capacity measurement - Composite Regional Resilience Capacity Index (CRRCI)

In Stage 1, the Composite Regional Resilience Capacity Index (CRRCI) is computed as a cross-sectional measure of the structural endowment of each NUTS2 region at the eve of the crisis. The CRRCI draws on all 17 indicators organized within the four pillars described above – social (5), economic (6), environment and infrastructure (3), and institutional (3) – and is calculated as an average over a short (three-year) pre-crisis window in order to smooth annual fluctuations and produce a stable portrait of structural conditions. All indicators are normalized to a common scale prior to aggregation and are oriented so that higher values uniformly indicate greater resilience capacity.

The pilot study adopts equal weights both across the four pillars and within them. The reason for this is more pragmatic than theory or methodology driven: with only ten regions included, a sophisticated data-driven tool such as Principal Component Analysis cannot be used, there are simply not enough datapoints. We readily acknowledge this as a limitation: equal weights embody the assumption that all indicators and pillars contribute in an identical manner to resilience capacity, which is difficult to defend on theoretical grounds. Planned future continuation of this research to the full population of EU NUTS2 regions (244 as of March 2026) would permit PCA-based weighting.

It is important to emphasize that this index does not aim to capture and measure resilience, since it cannot be reduced to a single cross-sectional score. CRRCI measures the structural preconditions for resilience: the constellation of human and economic resources, environmental conditions, infrastructural endowments, and governance quality that jointly determine a region's *potential* to absorb, adapt to, and recover from shocks. Whether this potential is realized during crisis is addressed in Stage 2.

4.3 Stage 2: performance measurement - Composite Regional Resilience Performance Index (CRRPI)

In Stage 2, three performance metrics – coping, bounce back, and bounce forward – are applied to a deliberately restricted subset of indicators selected primarily for their sensitivity to crisis-induced variation. Most indicators from the capacity index are excluded, because they follow trends with a lag effect or show no significant crisis-specific variation in a reasonable time horizon, for example perceptions of institutional quality (see Chapin et al. 2009 for "slow" and "fast" variables).

Our metrics are computed on five outcome-type variables:

- GDP per capita (PPS);
- the employment rate;
- net disposable household income;
- the NEET rate;
- share of persons at risk of poverty or social exclusion.

These variables span both economic and social pillars. To ensure a consistent interpretation of the results, the metric formulas for the NEET rate and poverty risk were adjusted so that higher values consistently represent better resilience outcomes rather than increased vulnerability. The indicator set for performance is intentionally smaller than the capacity set for two primary reasons. First, the logic of performance measurement dictates the use of outcome-type indicators that possess a clear theoretical link to resilience. We argue that several outcome variables used in previous frameworks, such as the JRC's (Benczúr et al. 2020) inclusion of *deathrate due to suicide* rate, can be called into question regarding the directness of their link to resilience performance during a crisis window, especially in a medium-run time horizon.

Second, this restricted selection facilitates complexity reduction and the avoidance of multicollinearity. For instance, the employment rate and the long-term unemployment rate listed alongside each other in the JRC's framework (Benczúr et al. 2020), despite clear concerns about overlapping domains. While this indicator set could be expanded in the future, any addition must be considered with the horizontal multidimensionality approach in mind.

The methodological framework for the performance metrics is similarly inspired by the work of Benczúr et al. (2020). Their study utilized an *Impact* metric, which we adopted in its entirety for our Metric 1 – *Coping*. They employed a Medium-run and Bounce Forward metric too, to assess how regions absorbed and transformed following a shock. We constructed two metrics, described below, with slightly different logic.

Metric 1 – *Coping* measures the severity of crisis impact by comparing the lowest observed value during the crisis period to the pre-crisis benchmark[10], capturing how much ground a region lost at the point of maximum distress.

Metric 2 – *Bounce back* measures recovery speed as the number of years required for a region to return to its pre-crisis benchmark level. If a region has not recovered by the end of the observation period, the metric is treated as

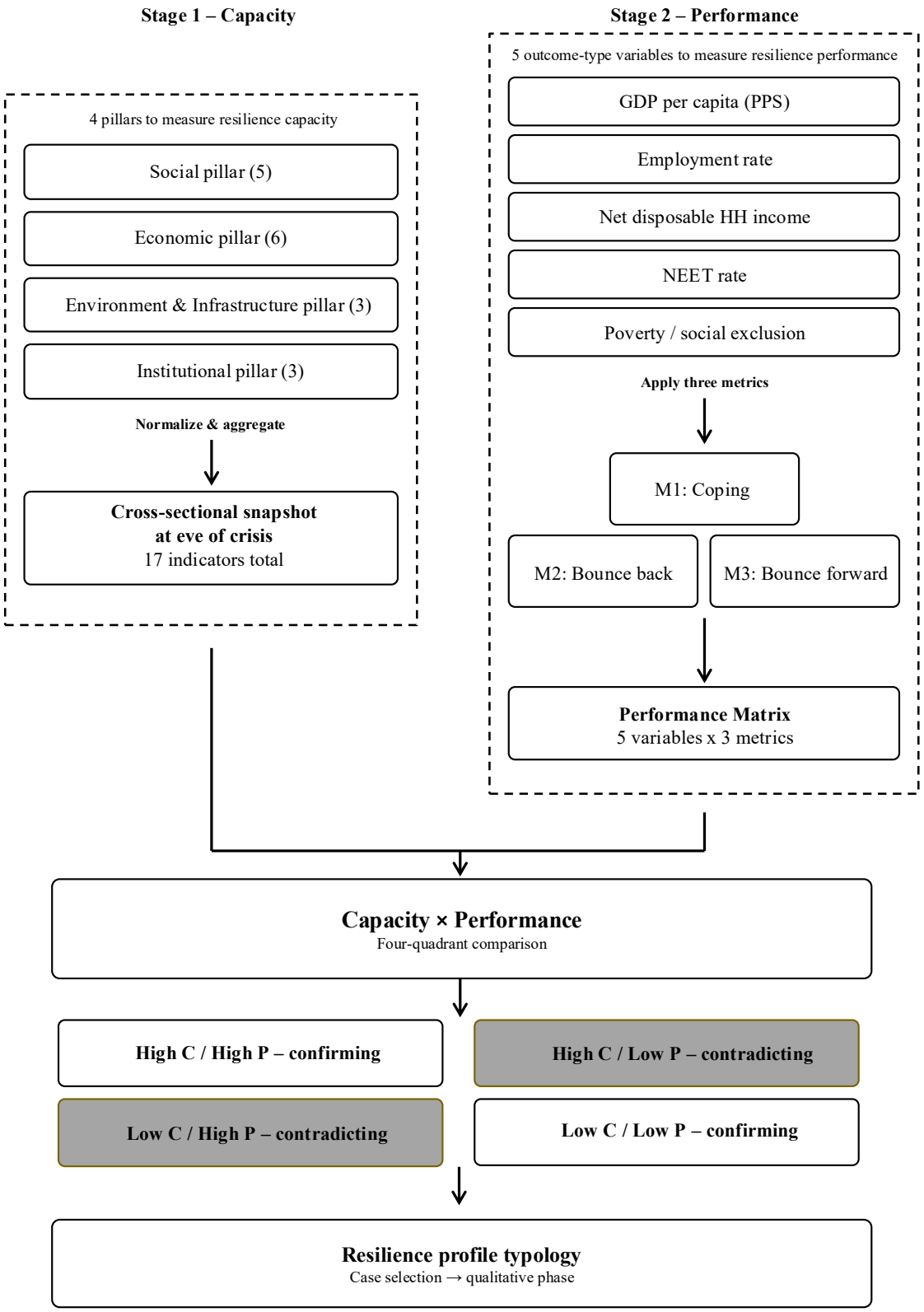
[10] The benchmark year is 2019, the last full calendar year preceding the onset of the Covid-19 pandemic in Europe.

a lower-bound estimate. A disclaimer about jargon needs to be expressed here: *bounce back* in this specific case is not meant to be understood as it is used in resilience theory; instead, it merely refers to the act of bouncing back to the pre-crisis benchmark level, with bouncing forward (i.e. reaching an improved state) still being part of the framework.

Metric 3 – *Bounce forward*[11] assesses whether a region emerges from the crisis on a qualitatively improved trajectory, rather than merely returning to its prior state. It does so by comparing the region's actual post-crisis level (in our case, the latest available datapoints from 2024) against a projection of where it would have been had its pre-crisis trend continued undisturbed. Positive values indicate that the region has exceeded its own pre-shock baseline, while negative values indicate underperformance.

Aggregating these metrics into a composite score starts with averaging for each region across indicators, which leaves us with three scores for every region. After that, Z-scoring is applied, and for logical consistency M2 (bounce back) is multiplied by -1 to flip it, so that fewer years to bounce back is taken as the better result. Finally, averaging the three correctly oriented Z-scores produces the composite index score.

[11] Winsorization was applied at the 5th and 95th percentiles to treat extreme outliers that occurred in some cases (particularly HU21 and RO42 in the case of poverty risk).



1. Structure and flow of the quantitative part. Created by the author with the assistance of Claude (Anthropic AI, Model: Sonnet 4.6) and Canva.

4.4 Resilience profiles

The analytical yield of the two-stage design is realized through the comparison of capacity and performance. This comparison is operationalized in two ways. First, a bivariate comparison is conducted by plotting the composite CRRCI score (Stage 1) against a summary performance measure (Stage 2, CRRPI) in a four-quadrant scatter plot. For the purposes of this pilot study, the four-quadrant comparison is operationalized by dividing the capacity and performance dimensions at their respective sample medians[12]. Regions with a CRRCI score above the median are classified as high-capacity; those at or below the median as low-capacity. The same logic applies to the composite performance score. Since this is a small-N pilot study, we don't have the necessary information and data to create thresholds or use other statistical tools to extract more statistically robust benchmarks. Consequently, the results merely highlight comparative performance variations within this specific sample.

Similarly to the previously described work of Briguglio et al. (2009) regarding economic vulnerability and resilience, our scatter plot generates four analytically significant quadrants, across capacity and performance: high capacity and high performance (confirming cases, where high capacities translated into effective crisis traversal); low capacity and low performance (confirming cases of structural vulnerability); high capacity and low performance (contradiction of underperformance, where strong endowments did not prevent poor outcomes); and low capacity and high performance (contradiction of overperformance, where modest endowments were compensated by other mechanisms). The cases located in the latter two quadrants are of the greatest interest to resilience scholarship, as they signal the presence of underlying factors – governance quality, network effects, institutional learning, or policy choices – that the indices alone cannot capture and that a future qualitative study is designed to uncover.

4.5 Case selection – the ten NUTS2 regions

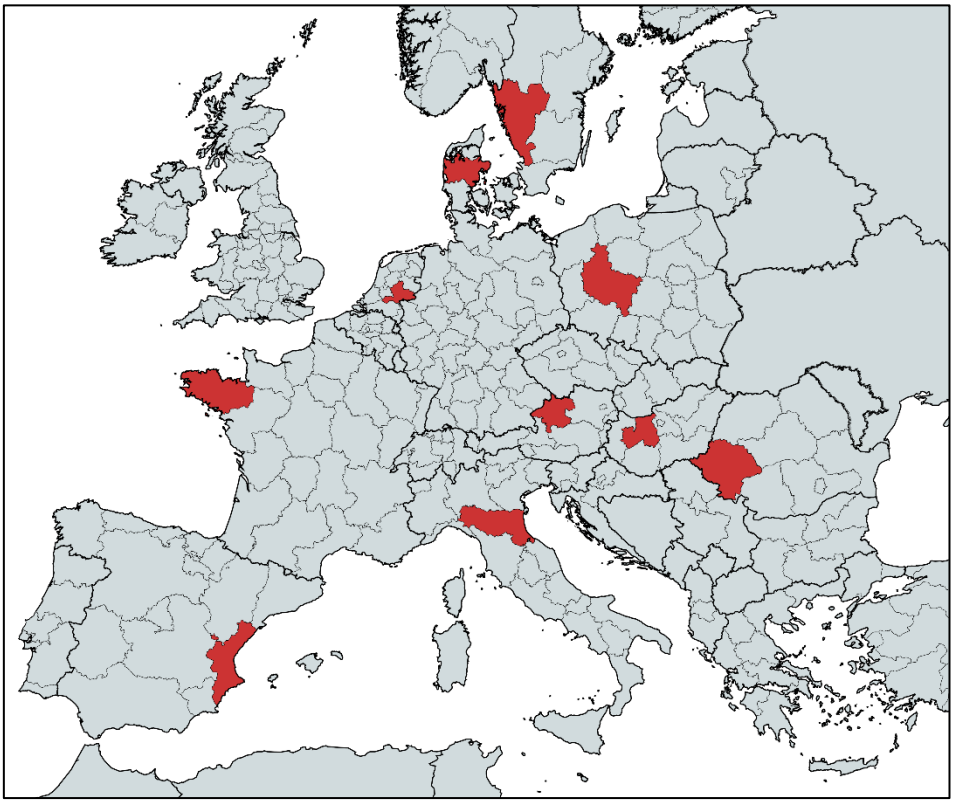
The ten NUTS2 regions were selected according to the three criteria below.

- ***Complete (or near-complete) data availability***: all 17 indicators must be available without critical gaps starting from 2017 – less data imputation is required.
- ***No capital regions***: capital regions were excluded to avoid non-representative, skewed data (concentration of national government, headquarters functions, commuter-driven economic activity).
- ***Geographic diversity***: representation of Northern, Western, Southern, and Central-Eastern Europe, spanning a range of economic and social development levels, as well as governance models and traditions.

Germany and Belgium were entirely excluded, because EQI data is only available at NUTS1-level. The final selection of ten regions was hand-picked by the author to fit the above criteria. The selected ten NUTS2 regions are the following, moving down the Mercator projection: ***Västsverige*** (Sweden, SE23); ***Midtjylland*** (Denmark, DK04); ***Wielkopolskie*** (Poland, PL41); ***Gelderland*** (Netherlands, NL22); ***Bretagne*** (France, FRH0);

[12] Median is preferred over the mean as the dividing threshold because it is robust to the influence of extreme values. In a small-N study this is a legitimate concern.

Oberösterreich (Austria, AT31); ***Közép-Dunántúl*** (Hungary, HU21); ***Vest*** (Romania, RO42); ***Emilia-Romagna*** (Italy, ITH5); ***Comunitat Valenciana*** (Spain, ES52).



2. Final selection of NUTS2 regions. Created by the author with the mapchart.net tool.

We anticipate a dominant East-West divide, particularly within the RO42 – HU21 – AT31 corridor: varying levels of economic and social welfare levels meet a shared supply-chain dependency (automotive industry). A North-South dimension is also expected to emerge, though not as stark as East-West divide, but we expect the Nordic regions to excel both in Stage 1 and Stage 2 metrics. Interesting results may also arise from the coastal Bretagne and Comunitat Valenciana regions, contrasting the tourist dependent Spanish region with a similarly culturally coherent, but economically diversified French counterpart.

5. Results

The primary interest of this pilot study rests not in the absolute scores, but in the *mechanical behaviour* of two-stage framework. In the following sub-sections, lessons will be drawn about experiences working with this design alongside the results. As we said before, generalizations beyond this specific sample require extension to the full population of EU NUTS2 regions. All CRRCI, as well as the individual pillar scores both range from 0 (weakest results) to 1 (strongest results), as a result of min-max normalization. CRRPI scores are standardized via Z-scoring, which means they can dip below zero. One methodological note needs to be reiterated: on a small-N pilot study, outliers can skew the data heavily.

Region / Code	Capacity CRRCI	Performance CRRPI	Quadrant
Västsverige SE23	0,731	-0,200	Q2: High C / Low P
Gelderland NL22	0,709	0,855	Q1: High C / High P
Midtjylland DK04	0,674	0,721	Q1: High C / High P
Oberösterreich AT31	0,585	-1,471	Q2: High C / Low P
Bretagne FRH0	0,508	-0,649	Q2: High C / Low P
Emilia-Romagna ITH5	0,459	0,493	Q3: Low C / High P
Comunitat Valenciana ES52	0,436	0,261	Q4: Low C / Low P
Wielkopolskie PL41	0,375	0,463	Q3: Low C / High P
Közép-Dunántúl HU21	0,365	0,306	Q3: Low C / High P
Vest RO42	0,323	-0,779	Q4: Low C / Low P

3. Final results, ranked by capacity scores.

5.1 Capacity results

The CRRCI produced a ranking that broadly follows what was expected from the socio-economic development across Europe. No severely (or even moderately) counter-intuitive results were received. The five high-capacity regions are Västsverige (0,731), Gelderland (0,709), Midtjylland (0,674), Oberösterreich (0,585), and Bretagne (0,508), from Sweden, the Netherlands, Denmark, Austria, and France respectively. The five low-capacity regions are Emilia-Romagna (0,459), Comunitat Valenciana (0,436), Wielkopolskie (0,375), Közép-Dunántúl (0,365), and Vest (0,323), from Italy, Spain, Poland, Hungary, and Romania.

The most interesting results are the following:

- Northen and Western Europe excel in capacity ranking – high social, economic, environmental and infrastructural, and institutional capacities through diversified economies, strong social safety nets and institutional trust are all present. The Swedish Västsverige region achieved the highest score on the environmental and infrastructure pillar (above 0,93), and on the economic pillar, too (0,81). Danish Midtjylland and Gelderland from the Netherlands follow closely, with similarly strong social, economic and institutional foundations.
- The weakest links are Vest (RO42) and Közép-Dunántúl (HU21). Both regions rely heavily on automotive industry, with HU21 featuring the least diversified economy and overall weakest economic foundations that translate to the lowest economic pillar score (0,23). Trust in institutions (aka *Quality of Government*

scores) is traditionally lower than that of Western European counterparts – the lowest result is 0,323 from RO42.

- An interesting contrast may be recognized between Oberösterreich (AT31) and Emilia-Romagna (ITH5). AT31 has one of the strongest economic and social pillar score, while it has a particularly low environment and infrastructure score (almost entirely because of its highest GHG per capita emissions in the sample, driven by the heavy manufacturing base in the Linz industrial corridor), while the reverse is true for ITH5.

5.2 Performance results

The performance analysis produces a substantially different ordering of the ten regions. The five high-performance regions are Gelderland (0,855), Midtjylland (0,721), Emilia-Romagna (0,493), Wielkopolskie (0,463), and Közép-Dunántúl (0,306). The five low-performance regions are Comunitat Valenciana (0,261), Västsverige (-0,2), Bretagne (-0,649), Vest (-0,779), and Oberösterreich (-1,471). Notably, three of the five highest-capacity regions – Västsverige, Oberösterreich, and Bretagne – fall into the low-performance group, while three of the five lowest-capacity regions – Emilia-Romagna, Wielkopolskie, and Közép-Dunántúl – fall into the high-performance group. The three constituent metrics are discussed individually below.

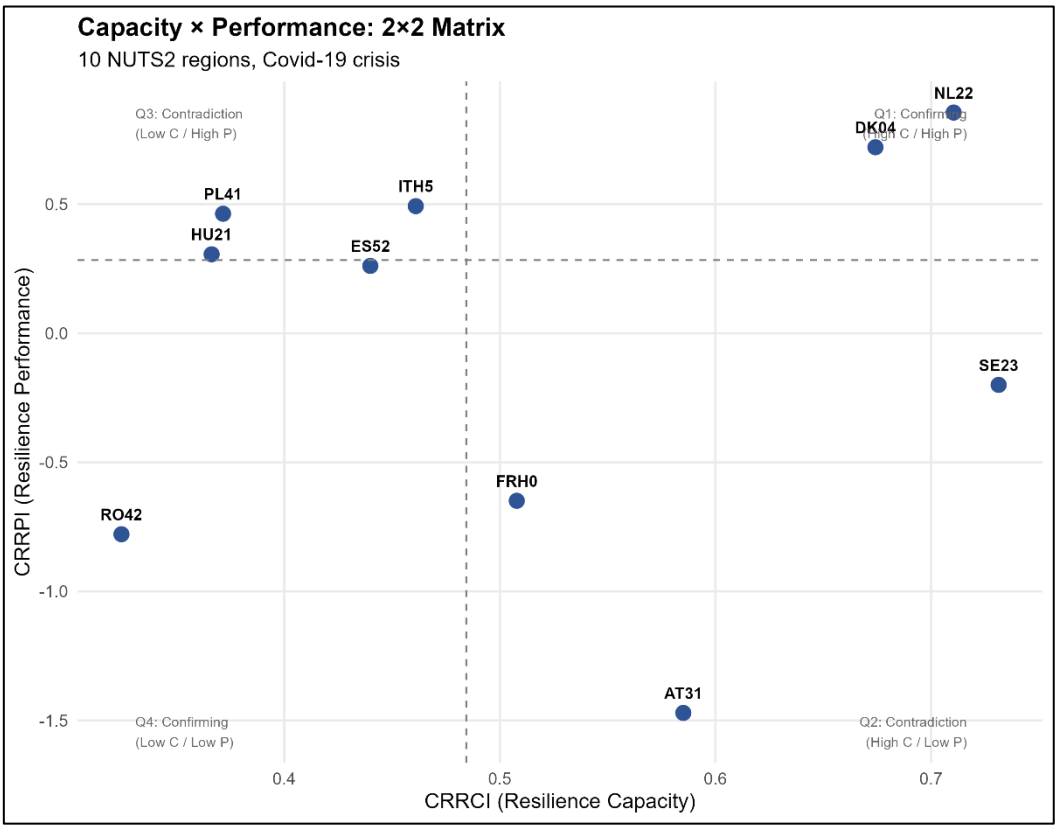
- ***Coping***. The coping metric captures the depth of the crisis-induced dip. The results reveal that the Covid-19 pandemic produced relatively low average dips across most regions: eight of ten regions recorded average coping scores between -0.04 and -0.08.
- ***Bounce back***. The bounce back metric measures the number of years required for each indicator to return to its 2019 benchmark level. Average bounce back times range from 1 year (in the cases of Gelderland and Midtjylland) to 3 years (in the case of Bretagne). The two fastest-recovering regions benefited from having several indicators that never dipped below benchmark (GDP, household income), resulting in values of zero for those indicators. A common pattern: GDP per capita and household income generally recovered within 1 to 2 years, while employment and NEET typically required 2 to 3 years.
- ***Bounce forward***. The bounce forward metric compares each region's actual 2024 value against a projection based on pre-crisis growth trends, meaning positive values indicate that the region exceeded its own projected trajectory, while negative values indicate a lasting crisis scar. Average bounce forward scores range from 0,23 (Emilia-Romagna) to -0,03 (Oberösterreich, the only region with a negative average). A pattern arising: GDP per capita and household income show positive bounce forward values across cases, suggesting that aggregate economic output recovered and exceeded pre-crisis trends. Employment, however, shows negative bounce forward values for seven of ten regions, suggesting a lasting structural shift in labour markets.

5.3 The four quadrants

The four quadrants were populated in the following manner:

- ***Q1*** (high capacity / high performance) contains *Gelderland* (NL22) and *Midtjylland* (DK04) – confirming cases where strong foundations translated into effective crisis traversal.
- ***Q2*** (high capacity / low performance) contains *Västsverige* (SE23), *Oberösterreich* (AT31), and *Bretagne* (FRH0) – the cases of contradiction by underperformance.
- ***Q3*** (low capacity / high performance) contains *Emilia-Romagna* (ITH5), *Wielkopolskie* (PL41), and *Közép-Dunántúl* (HU21) – the cases of contradiction by overperformance.
- ***Q4*** (low capacity / low performance) contains *Comunitat Valenciana* (ES52) and *Vest* (RO42) – confirming cases.

The distribution – two Q1 confirmers, three Q2 contradictions, three Q3 contradictions, and two Q4 confirmers – reveals a weak and slightly negative correlation between capacity and performance within this sample. A similarly strong pattern in the full NUTS2 population would lead us to the conclusion that *structural endowments do not deterministically predict crisis outcomes*.



4. Results across the four quadrants. Created by the author in R with the assistance of Claude (Anthropic AI, Model: Opus 4.6).

5.4 Lessons regarding the framework and methodology

In terms of mechanical behaviour, the framework performed as anticipated. That is to say, the output aligned with the underlying logic of the model. Variations that did arise were not indicative of systemic errors within the framework, but they were explained by the specific parameters of data treatment and the inherent constraints associated with a small-N study. Analysis was conducted to check if quadrants changed with different

normalization methods (Z-scoring applied to CRRCI, where originally min-max normalization was used), which did not result in changes. Analysis was also conducted to check how the behaviour changes if one indicator is left out (*leave-one-out* sensitivity test): mild changes occurred in the case of CRRCI, while CRRPI showed a medium degree of sensitivity, which is explained by the fact that only five indicators are used in performance measurement. Consequently, the framework demonstrates a sufficient degree of consistency and reliability.

The flexibility which this methodological arrangement offers is a considerable asset. Utilizing highly reliable Eurostat, EDGAR and EQI mostly "hard-data" lends us robustness that supports cross-regional comparisons across Europe. To maintain the integrity of the framework, data imputation must be done in a strictly consistent manner. In this current iteration of the study, backfilling was employed to address partial missing data (for example in the case of poverty and social exclusion for Oberösterreich, AT31), while higher-level NUTS1 data was utilized in place of entirely missing datasets (for example R&D expenditures per capita for Gelderland, NL22).

6. Conclusion

While the current framework is functional and offers a comprehensive synthesis of regional resilience measurement approaches, it represents a foundational step rather than a final iteration. Future work must prioritize the finalization of indicator selection and theoretical grounding, while exploring the options to expand the performance indicator set. To ensure the integrity of the model, advanced statistical tools must be integrated to identify possible underlying data issues, such as multicollinearity. Addressing redundant correlations between variables, the framework can provide a clearer picture of the unique contributions of each indicator to capacity and performance indices.

To fully capture a region's resilience in the long-term, the conceptual framework could also be expanded to include transformability and exaptive potential (see Iotzov – Kollár, 2025 for exaptive dimension of territorial resilience). Future research directions may include conceptualizing and operationalizing the concept of antifragility (Taleb, 2012). Antifragility is described as a distinct state from resilience, in which antifragile entities – let them be states, regions, communities or institutions – benefit and grow from disruptions. Building upon existing literature and recent regional studies, such as Kwaśny et al. (2026), future iterations of this study may focus on analysing and incorporating antifragility into measurement.

Future research may also include another crisis event – the 2008 financial crisis comes naturally – for historical validation purposes. The Covid-19 pandemic hit the world as a "perfect storm", which also created ample opportunity to theorize and test resilience frameworks with a general appeal, but taking another, more specific disruptive event as a separate test would build robustness and provide meaningful feedback for fine-tuning. The greatest limitation for all current Covid-19 resilience studies is the sheer fact that most available data still only date up to 2024 – years into the future, opportunity for true long- and medium-term performance measurement will arise.

Overall, the primary contribution of this study lies in its separation of capacity and performance, operationalized in a two-stage empirical design. With the 2x2 analytical matrix, the framework moves beyond one dimensional, index-based rankings to flag contradicting cases that demand qualitative explanation. Indicator selection and fine-

tuning of metrics is the next step in setting up the stage for a thorough comparative case study, concluding the mixed methods explanatory design.

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