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From shock response to structural change: linking the dimensions of regional resilience

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ABSTRACT

This study examines how short-term regional economic resilience relates to longer-term structural change across EU NUTS (nomenclature of territorial units for statistics)-2 regions. We operationalise regional economic resilience as four dimensions, i.e., resistance, recovery, reorientation and renewal, and focus on the interrelationships among these dimensions. First, a systematic literature review maps the indicators used to assess resilience across the four dimensions. Second, we bring these insights into an empirical setting by assessing EU NUTS-2 regions using gross domestic product (GDP) and employment-based measures to capture the four dimensions in a consistent framework. The results show that regional resilience is not a linear progression from stabilisation to transformation. The links with renewal are mixed: recovery is only weakly positively associated with employment-based renewal, whereas better resistance is significantly associated with stronger GDP-based renewal. Overall, the findings indicate that cushioning short-term losses should be paired with capability-building measures if reorientation and renewal are explicit policy objectives.

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Regional economic resilience; resistance; recovery; reorientation; renewal; long-term resilience; short-term resilience

JEL
R11; R12; R15; E32

1. Introduction

Regional economies increasingly face recurrent and overlapping shocks, from financial turbulence and supply-chain disruptions to geopolitical instability and climate-related events, testing not only their capacity to absorb disturbances but also their ability to resist, recover, renew and reorient. This has placed regional economic resilience (RER) at the centre of scholarly and policy debates, particularly in Europe, where cohesion policy and place-based development strategies depend on credible evidence about how regions respond to adversity. However, despite the growing volume of RER research, the field still struggles to provide a consistent, time-sensitive overview of resilience that can be compared across studies and meaningfully interpreted for regional trajectories (Banica et al., 2024). A key challenge is that empirical work often privileges short-run stabilisation over long-run structural change (Davies, 2011; Webber et al., 2018). Different studies operationalise resilience using different indicators and modelling choices, sometimes targeting immediate post-shock performance and sometimes capturing longer-term adaptation or transformation. As a result, the evidence base is fragmented: what counts as resilience varies with the time horizon and the aspect of resilience under study (Lazzeretti et al., 2022). This weakens cross-study comparability and obscures whether short-term outcomes are associated with longer-term transformation. Against this backdrop, a time-aware synthesis is needed to clarify which indicators and methodological approaches are used to assess RER across short- and long-term horizons, and to what extent the literature explicitly addresses linkages between these horizons.

Given these complexities, examining RER across distinct resilience characteristics enables a more differentiated assessment of how regions respond to shocks across short- and long-term horizons. Martin's (2012) seminal evolutionary perspective conceptualises regional economic resilience as a multidimensional and adaptive process encompassing resistance, recovery, reorientation and renewal. This four-fold typology

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provides a structured framework to capture both an equilibrium-oriented perspective, emphasising short-term adjustment through resistance and recovery, and an adaptive perspective, focusing on longer-term change through reorientation and renewal.

However, while Martin's (2012) perspective offers a valuable lens to conceptualise diverse regional responses to disruptions, its empirical application remains far from straightforward (Sabatino, 2019). The boundaries between the four dimensions are often fuzzy, as regions rarely exhibit a single, clearly separable form of resilience; instead, responses typically combine multiple modes that shift with the duration, nature and scale of the shock (Sensier et al., 2024). Moreover, there is no clear scientific consensus on how to operationalise and assess these distinct responses (van Bergeijk et al., 2017). While there is relatively more convergence on measuring resistance and recovery, substantially greater uncertainty surrounds how to evaluate regional capacity to adapt and transform through reorientation and renewal (Xiao et al., 2018). Finally, the seminal work by Boschma (2015) remains highly relevant today, underscoring one of the still unresolved questions in the regional resilience literature: empirical evidence is limited on how resilience responses interrelate, specifically, whether higher resistance translates into faster recovery, and whether short-term performance is also associated with a stronger, longer-term capacity to reorient and renew regional development trajectories.

To address these research gaps, this study advances RER research in two steps. First, it conducts a systematic literature review (SLR) to (i) identify the indicators used to assess and forecast RER across the four resilience dimensions, i.e., resistance, recovery, reorientation and renewal, and (ii) examine the extent to which prior work acknowledges interconnections among these dimensions, particularly between short-term (resistance, recovery) and long-term (reorientation, renewal) dynamics. Second, it brings these insights into an empirical setting by assessing the RER of EU NUTS (nomenclature of territorial units for statistics)-2 regions through the same four-dimensional lens.

The empirical application covers 2009–2024 and is implemented under the NUTS 2024 framework (244 NUTS-2 regions), ensuring a territorially comparable EU-27 sample. Within this setting, COVID-19 provides a common, sharp, and temporally concentrated shock. We therefore assess all four resilience dimensions using a common sensitivity-index framework and pairwise correlations to examine whether short-term resistance and recovery are associated with subsequent reorientation and renewal.

This paper contributes to the RER literature in several ways. First, it advances the evolutionary perspective on RER by providing a systematic, time-aware synthesis of how resilience is operationalised across short- and long-term horizons, and by systematising the indicators used to study resistance, recovery, reorientation, and renewal. Second, it translates these insights into an empirical assessment of EU NUTS-2 regions within a territorially comparable EU-27 setting, using the current NUTS 2024 classification and a consistent four-dimensional framework. Third, it addresses a persistent gap concerning linkages among resilience dimensions by examining inter-dimensional associations, shedding light on how short-term outcomes relate to longer-term reorientation and renewal.

2. Literature review

2.1. Retrieval of publications

Although RER is well established in economic geography and regional economics, debate continues over its precise definition and empirical operationalisation. Any empirical study must therefore specify resilience to what shock, of which dimensions, and over what time horizon (Faggian et al., 2018). These issues are especially important because different resilience dimensions serve different analytical purposes, from short-term shock absorption to longer-term structural adaptation (Sabatino, 2019). To address this gap, we conducted an SLR guided by two review questions:

- Q1: What are the most frequent indicators used to analyse distinct dimensions of regional economic resilience (resistance, recovery, reorientation, renewal)?
- Q2: To what extent does the existing literature acknowledge and examine the interconnections between different RER dimensions, particularly between the short-term (resistance, recovery) and longer-term (reorientation, renewal)?

To ensure transparency and replicability, the review follows the PRISMA (preferred reporting items for systematic reviews and meta-analyses) guidelines. In the first step, we retrieved publications relevant to these review questions. We began by selecting keywords that would allow us to remain as inclusive as possible while staying aligned with the notion of RER. We therefore focused on the broad phrase 'regional economic resilience', on the premise that any typology, evaluation framework or empirical analysis of specific resilience types necessarily builds upon the foundational concept of RER, using the Boolean operators AND and OR. We formulated search strings tailored to each database's logic.

For Web of Science, the search query was: *TS = ('economic' AND 'regional' AND 'resilience') AND LA = (English) AND DT = (Article) AND WC = ('Economics').*

For Scopus, we used: *TITLE-ABS-KEY('economic' AND 'regional' AND 'resilience') AND (LIMIT-TO(SUBJAREA, 'ECON')) AND (LIMIT-TO(DOCTYPE, 'ar')) AND (LIMIT-TO(LANGUAGE, 'English')).*

These queries yielded a total of 866 articles. Subsequently, we conducted a screening process based on pre-defined inclusion and exclusion criteria. In selecting relevant studies, we restricted the sample to empirical articles that evaluated RER at the regional scale (rather than, for example, national, firm-level or purely conceptual analyses). To capture as many relevant studies as possible, we searched two major bibliographic databases: Scopus and Web of Science. From Scopus, we included all publications categorised under Economics, Econometrics, and Finance that matched the search query. From Web of Science, we included all scientific outlets classified in the Economics subject category. Regarding document type, we considered only peer-reviewed journal articles, excluding conference proceedings, book chapters and book reviews to ensure a consistent level of scientific scrutiny and comparability. No starting year was imposed on the search in order to include all relevant publications since the emergence of the RER concept. The time frame thus covers all articles published up to January 2025. Finally, we limited the review to articles written in English to ensure consistency in the interpretation and coding of concepts, indicators, and methodological approaches.

Based on the search query, 866 scientific articles were identified. However, after applying the eligibility criteria and removing duplicates, 168 articles remained to be further screened by analysing their titles, abstracts, and keywords using the reference manager Zotero. This step resulted in 98 articles, which were then thoroughly appraised. This phase entailed screening entire texts, and 14 publications were excluded, primarily because they lacked sufficient information regarding research design or methods. Overall, during the inclusion stage, we retrieved 84 articles used in the study's further review. The process for an archetypal SLR is presented in Figure 1.

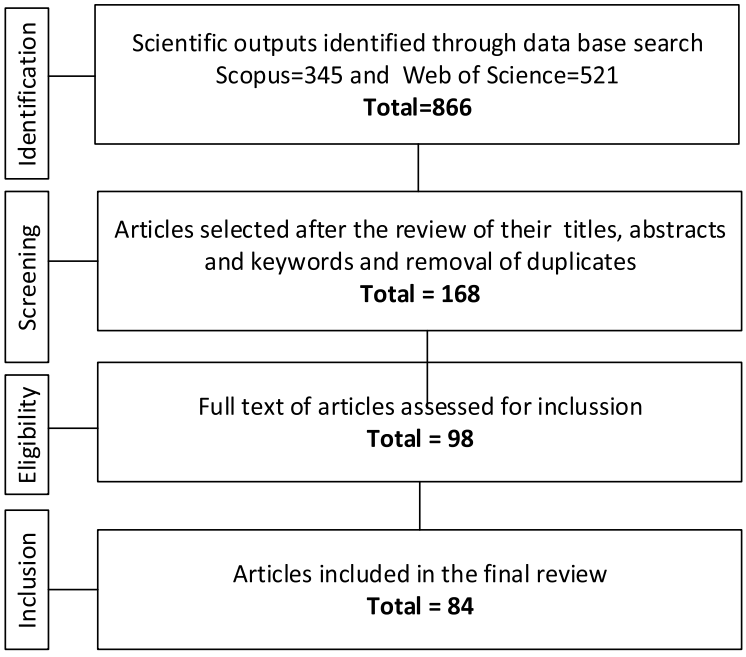

Figure 1. Flow diagram indicating the PRISMA review process.

2.2. Bibliometric findings

The next phase involved literature synthesis, conducted using a deductive coding strategy grounded in Martin's (2012) RER typology. Specifically, the coding framework was predefined around four dimensions, i.e., resistance – the degree of sensitivity or depth of reaction to the shock; recovery – the speed and degree of recovery from the shock; reorientation – the extent to which the region adapts and re-orientates in response to the shock; and renewal – the degree to which the region resumes its pre-shock growth path (Martin, 2012; Webber et al., 2018). Each reviewed article was analysed through this lens to systematically capture how empirical studies operationalise and assess RER across these four dimensions.

The synthesis of 84 empirical studies on regional economic resilience shows that RER research remains strongly concentrated in the European Union. The reviewed evidence indicates that most contributions focus on EU NUTS-2 regions (see Table 1). In contrast, retrieved papers did not include studies that adopt a broader cross-continental perspective. This limited geographical coverage can be seen as a substantive gap, because regions are embedded in global systems of interdependence. Consequently, shocks can spread across territories via production linkages and logistics disruptions, implying that resilience patterns observed in EU NUTS-2 settings may not fully capture RER dynamics in more diverse contexts. Our findings suggest that, regardless of geographical context, RER is most frequently investigated through the lenses of resistance and recovery. In contrast, research assessing regions' capacities to adapt and transform remains limited, indicating a clear gap in the empirical literature.

In the next stage, applying open-coding principles, we assessed which indicators were used to evaluate RER. Synthesising the reviewed sources enabled us to identify four main thematic areas that emerged from the indicators used in the retrieved papers to examine RER (see Table 2). The results indicate that most studies employ indicators of employment and gross domestic product (GDP).

Table 1. Distribution of retrieved empirical studies by regional unit.

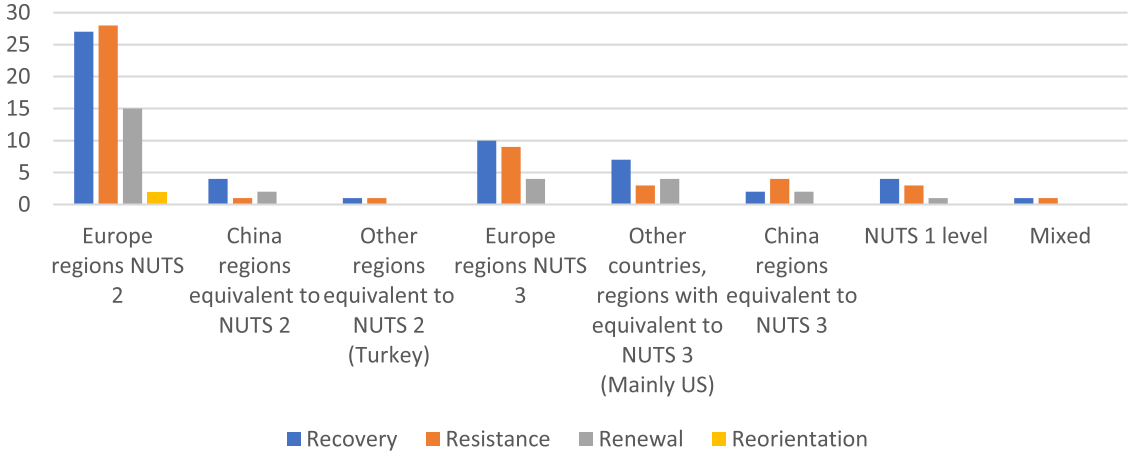

Table 2. Thematic areas of indicators used to assess RER in the retrieved papers.

Aggregated indicator themes	Indicators employed in the retrieved papers	Number of articles	%
Employment based	Employment dynamics; unemployment rate; gender balanced employment; labour mobility; sectoral changes in workforce numbers.	48	57
GDP based	GDP growth rate, GDP per capita, and labour productivity.	23	27
Composite and Multidimensional indices	Resilience index (peripherality: accessibility, distance to political centres, regional development); Regional Resilience Index; Night-time-lights resilience index (deviation and recovery vs pre-shock trend); Economic performance (GDP per capita, employment, labour productivity); Regional economic resilience composite (community links, human capital, labour market, economic performance, innovation).	8	10
Other RER indicators	Annual change in intermediate consumption (county level); technology-space network robustness; Regional economic activity (employment, exports, firm dynamics); Trade resilience (recovery in trade volume, collapse duration, post-crisis growth); Industrial resilience (measured through adaptation and adaptability of pillar industries before and after natural hazards).	5	6
Total		84	100

Table 3. Indicators used to measure specific RER dimensions.

Indicators:	Recovery	Resistance	Reorientation	Renewal
Employment based	33	32	15	1
GDP based	14	14	5	1
Composite and multidimensional indices	5	3	5	
Proxy based	3		2	

When examining the indicators used to assess RER across its dimensions, it is evident that most synthesised studies focus on short-term RER, primarily capturing the resistance and recovery dimensions using employment and GDP-based indicators. Interestingly, long-term RER assessments also predominantly rely on these two indicator groups. Notably, many of the reviewed articles, when assessing RER from a short-term perspective, incorporate both resilience dimensions (resistance and recovery) and, in many cases, employ both employment- and GDP-based measures simultaneously. Overall, these two indicator types remain the most frequently used to explore RER, regardless of the specific dimension under investigation (see Table 3).

Nevertheless, the diversity of scientific perspectives indicates that there is no universally accepted single indicator that best captures regions' ability to withstand and respond to a changing environment; therefore, many studies examine RER from both employment and GDP perspectives.

2.3. Interconnections between short- and long-term RER dimensions

Most studies that focus on short-run RER explore the phenomenon through resistance and recovery dimensions (Martini, 2020; Sabatino, 2019; Salvati et al., 2017). Resistance shows whether a region avoids an economic downturn after a shock, while recovery describes how fast it returns to its pre-shock peak once a decline occurs (Banica et al., 2024). Following Webber et al. (2018), regions can be grouped as resistant (no downturn), recovered (downturn but back to pre-shock peak within three years), not recovered: upturn (improves but still below the pre-shock peak after three years) or not recovered: downturn (still no upturn after three years). However, recent reviews emphasise that such outcome-based classifications capture only one part of RER, because they mainly describe observed performance rather than the adaptive capacity and system change through which regions respond to shocks (Breglia & Modica, 2025; Sutton et al., 2023).

When the review is extended to a long-term perspective, the literature increasingly adopts evolutionary reasoning (Bristow & Healy, 2018; Sutton & Arku, 2022). In this view, RER can be assessed through reorientation and renewal (Ileanu & Pana, 2024). From this perspective, and more explicitly in Sutton and Arku's (2022) system approach, resilience is best understood as a property of regional economies conceived as systems; accordingly, reorientation should not be read as generic post-crisis change, but as a change in the structures and functions through which a region organises production, knowledge creation, labour and institutional support. While reorientation captures whether the crisis triggered structural change, meaning that a region shifted activity toward more resilient sectors, rather than returning to the same pre-crisis structure (Rocchetta et al., 2022), renewal reveals whether the region improved its long-term growth trajectory relative to the pre-crisis period (Martin, 2012). The latter reflects whether a region resumes its previous growth path or shifts to a new growth trend, and it is typically supported by innovation (Bishop, 2019; Bristow & Healy, 2018; Compagnucci et al., 2022; Filippetti et al., 2020), restructuring (Rocchetta et al., 2022; Sánchez & Cuadrado-Roura, 2024; Zhang et al., 2024), labour-force upgrading (Cutrini, 2023; Fratesi & Perucca, 2018; Padgureckienė & Butkus, 2024) and institutional support (Hodzic & Fucar Sukic, 2024; Sensier et al., 2016; Song et al., 2024; Tupy et al., 2021; Wang et al., 2022). This interpretation is consistent with Sutton and Arku's (2022) systemic approach, which holds that the type of resilience displayed by a region depends on the extent to which its economic system changes structurally and functionally during and after a shock.

Pontarollo and Serpieri (2020) suggested that renewal can be measured by calculating the difference between the slopes of GDP growth trends before and after a crisis, indicating whether the post-crisis growth path becomes stronger or weaker with a national (Di Caro, 2017; Sensier et al., 2024) or regional (Brakman et al., 2015; Compagnucci et al., 2022) benchmark. Thus, renewal is not only a question of whether a region grows again, but whether the post-shock growth path reflects a more favourable structural trajectory. In this sense, the literature on regional structural change becomes central to RER, because sectoral recomposition,

technological upgrading, labour reallocation and institutional coordination shape whether a shock produces path restoration, path adaptation or a deeper transformation.

Interestingly, Martin (2012) notes that countries exposed to severe and frequent shocks, such as recessions, financial crises and political disruptions, tend to display weaker long-term growth, and evidence suggests that deep recessionary shocks can depress long-term growth trajectories. At the same time, Martin (2012) highlights that major shocks may trigger or accelerate pre-existing structural change, producing either negative or positive hysteresis and, therefore, a new (lower or higher) growth trend. This argument creates a central issue for the literature on interconnections: short-term and long-term resilience do not necessarily move together in a simple linear way. This claim was evident in Bristow and Healy's (2018) study, which showed that short- and long-term recovery are not directly linked, emphasising that recovery speed and duration depend strongly on regional innovation capacity. Their study found that regions that resisted the 2007–2008 crisis in Europe tended to exhibit the highest innovation capacity and performance (Bristow & Healy, 2018). Therefore, short-term stabilisation should not be treated as a sufficient condition for long-term renewal; it may preserve the existing path, but it does not necessarily generate structural upgrading (Lazzeretti et al., 2022).

Within this logic, reorientation can be interpreted as a directional shift toward a more knowledge- and technology-intensive regional structure, rather than as generic structural change. At the same time, the literature indicates that diversified regions tend to outperform specialised ones (Bishop, 2019; Hassink, 2010; Li, 2024) because narrowly specialised economies are typically dominated by industries with similar knowledge bases, making their growth trajectories dependent on a limited set of sectors. Such regions are more vulnerable to lock-in dynamics: functional, cognitive and political lock-ins reduce redundancy and variety, constrain recombination across knowledge fields, and limit branching into new activities (Boschma, 2015). Consequently, specialised regions often require the infusion of new industries from outside the region to revitalise and strengthen their industrial base (Li, 2024). That said, specialisation in high technologies, measured in both employment and output, remains a positive regional asset for crisis resistance and post-recession recovery, especially when combined with innovative capacity (Eraydin, 2016, p. 9). Accordingly, effective reorientation is best understood not as persistence in a narrow specialisation, but as a transition in which regions broaden their adaptive base while increasing high-technology intensity. This also clarifies the link between RER and regional structural change: resilient regions are not simply those that return to previous activity levels, but those that can recombine existing capabilities, attract or develop new activities and redirect resources toward more productive and knowledge-intensive paths (Compagnucci et al., 2022). Regions that achieve this are more likely to connect short-term stabilisation with long-term renewal. A stronger high-tech employment base supports faster capability adaptation, a stronger high-tech output reflects deeper production restructuring and, together with innovation capacity, labour-force upgrading and institutional support, these changes strengthen sustained post-crisis growth (He et al., 2023).

To summarise the evidence from the literature review, most empirical studies included in the SLR examine short-term resilience, focusing on regions' capacity to withstand and recover from shocks. The synthesis also indicates that, regardless of the specific RER typology applied, the assessment of RER most commonly relies on employment-based and GDP-based indicators. However, recent conceptual and review-based contributions suggest that RER should be interpreted not only as observed post-shock performance, but also as a system-level process involving adaptive capacity, structural change and the reconfiguration of regional growth paths (Breglia & Modica, 2025; Sutton et al., 2023; Sutton & Arku, 2022). Finally, while the literature offers numerous theoretical arguments about the interconnections between short-term and longer-term RER, empirical testing of these linkages remains limited. To help address this research gap, the next section of the article empirically examines the relationships among the four RER dimensions, i.e., resistance, recovery, reorientation and renewal.

3. Methodology

Building on evolutionary economic geography, we examine four RER dimensions: resistance (Res), recovery (Rec), reorientation (Reo) and renewal (Ren). The analysis uses annual Eurostat data for 244 EU NUTS-2 regions over 2009–2024 under the NUTS 2024 framework. The employment (ages 15–74) rate (ER) is drawn from *lfst_r_lfe2emprt*; per capita GDP from nama_10r_2gdp (deflated using the GDP implicit deflator

(2020 = 100) from nama_10_gdp); and the high-technology employment share (HTER) from htec_emp_reg2. For each indicator, the EU27 benchmark uses the same variable definition aggregated to the EU27 level.

We centre the empirical analysis on COVID-19 because it provides the most suitable common shock for identifying short- and longer-term resilience dimensions in a territorially comparable EU-wide setting. The Great Financial and Sovereign Debt crises are retained only for context; 2014–2019 define the pre-crisis regime, 2020 the crisis year, and 2021–2023 the post-crisis regime (see Table A1 in Appendix A in the online supplemental data). All measures rely on the sensitivity index (SI) of Martin et al. (2016), which operationalises the four regional economic resilience dimensions against a common EU27 benchmark. Our aim is not to build an omnibus resilience score, but to assess whether the four dimensions are empirically linked within one internally consistent framework.

In the formulas below, r denotes region, eu the EU27 benchmark. For renewal, β_{pre} and β_{post} denote the pre- and post-crisis linear trend slopes.

Resistance reveals the region's ability to absorb the initial shock and limit the decline in the employment rate. Regions that experience smaller employment losses relative to the EU27 are considered more resistant. Following Di Caro and Fratesi (2023) and Martini (2020), resistance is measured by comparing the decline in the regional employment rate from the pre-crisis maximum to the crisis minimum with the corresponding decline in the EU27:

$$SI_{Res_r} = \frac{(ERr^{min}_{crisis} - ERr^{max}_{pre-crisis})/ERr^{max}_{pre-crisis}}{(EReu^{min}_{crisis} - EReu^{max}_{pre-crisis})/EReu^{max}_{pre-crisis}}. \quad (1)$$

Recovery reveals how strongly a region rebounds after the crisis. Stronger rebounds indicate better recovery performance (Webber et al., 2018). Recovery compares the increase in employment from the crisis minimum to the post-crisis maximum relative to the EU27:

$$SI_{Rec_r} = \frac{(ERr^{max}_{post-crisis} - ERr^{min}_{crisis})/ERr^{min}_{crisis}}{(EReu^{max}_{post-crisis} - EReu^{min}_{crisis})/EReu^{min}_{crisis}}. \quad (2)$$

Reorientation reveals regions' capacity for long-term structural adjustment. Unlike resistance and recovery, which focus on employment levels, reorientation captures whether the crisis triggered structural change toward more dynamic sectors (Silva et al., 2021). We use *HTER*, defined as the share of total employment in high-technology manufacturing and knowledge-intensive high-technology services, as a proxy for structural upgrading due to its association with productivity, innovation and post-crisis growth (Cutrini, 2023; Eraydin, 2016; Filippetti et al., 2020; He et al., 2023). We calculate reorientation as the change in the average share of high-technology employment between the pre-crisis and post-crisis period relative to the EU27:

$$SI_{Reo_r} = \frac{(HTERr^{mean}_{post-crisis} - HTERr^{mean}_{pre-crisis})/HTERr^{mean}_{pre-crisis}}{(HTEReu^{mean}_{post-crisis} - HTEReu^{mean}_{pre-crisis})/HTEReu^{mean}_{pre-crisis}}. \quad (3)$$

Renewal allows us to determine whether the region not only recovers from the crisis but also improves its long-term growth trajectory relative to the pre-crisis period (Pontarollo & Serpieri, 2020). This approach enables examining RER beyond short-term impacts by assessing post-crisis growth dynamics using both indicators, i.e., employment and GDP. For each region, we estimate linear trends for two distinct regimes: pre-crisis and post-crisis.

$$ER(or\ GDP)r_{regime,t} = \alpha^{regime}_r + \beta^{regime}_r t + \varepsilon^{regime}_{r,t}. \quad (4)$$

The slopes $\beta^{post-crisis}_r$ and $\beta^{pre-crisis}_r$ represent the respective regime's growth rates. Renewal SI compares relative improvement in the region's growth slope to the EU27 benchmark:

$$SI_{Ren_r} = \frac{\beta^{post-crisis}_r / \beta^{pre-crisis}_r}{\beta^{post-crisis}_{eu} / \beta^{pre-crisis}_{eu}}. \quad (5)$$

Descriptive statistics for all constructed resilience measures are reported in Table A2 in Appendix A in the online supplemental data and provide a first overview of their cross-regional dispersion. Interpretation of SIs values across different resilience dimensions is presented in Table 4.

Table 4. Interpretation of sensitivity index values across resilience dimensions.

	Resistance		Recovery		Reorientation		Renewal	
SI	Interpretation	DoI	Interpretation	DoI	Interpretation	DoI	Interpretation	DoI
>1	The region's employment **decreased more than in the EU27** during the crisis. This indicates **weaker resistance** and greater vulnerability to the shock.	↓	The region's employment recovered **faster than the EU27**. The rebound from the crisis minimum to the post-crisis maximum is stronger than the EU average.	↑	The region's high-tech employment share **increased more than the EU27**. This indicates **strong positive reorientation** and above-average structural upgrading.	↑	The region's long-term post-crisis growth **improved substantially more than in the EU27**. The region strengthened its growth trajectory, while the EU average declined.	↑
=1	The region's employment decline is **exactly the same as in the EU27**. The region reacted to the crisis with identical intensity.	↓	The region's recovery is **equal to the EU27**. The improvement in employment mirrors the EU benchmark.	↑	The region's increase in high-tech employment share is **equal to the EU27**. Structural adaptation matched the EU benchmark.	↑	The region's change in growth trajectory is **equal to the EU27's decline**. The region also experienced a deterioration from pre-crisis to post-crisis that is proportional to the EU trend.	↑
<1	The region's employment **decreased less than in the EU27**. This reflects **higher resistance**, as the region absorbed the shock better.	↓	The region's employment recovered **more slowly than the EU27**. The rebound is weaker relative to the benchmark.	↑	The region's high-tech employment share increased **less than the EU27**, indicating **weaker reorientation** or slower structural upgrading.	↑	The region's growth-path change is **weaker than in the EU27**, meaning its long-term trajectory deteriorated *more* than the EU average.	↑
=0	The region's employment **did not decline at all** during the crisis. This indicates **very strong resistance**, outperforming the EU average.	↓	The region **did not recover at all** from the crisis. Employment remained at the crisis minimum.	↑	The region's high-tech employment share **did not change at all**. Since the EU increased, this reflects a **relative structural decline** compared to the EU benchmark.	↑	No change in the region's slope (flat pre- vs post-crisis trend). Since the EU slope declined, this indicates **better renewal than the EU average**, even though growth did not accelerate.	↑
<0	The region's employment **increased during the crisis**, meaning it performed in the opposite (positive) direction to the EU27. This represents **exceptionally strong resistance**.	↓	The region's employment **continued to decline even after the crisis**, indicating severe post-crisis deterioration.	↑	The region's high-tech employment share **decreased**, moving in the opposite direction of the EU27. This indicates **strong negative reorientation** or structural regression.	↑	The region's slope turned negative (post-crisis decline), representing a **strong deterioration** in long-term growth dynamics; renewal is negative and significantly worse than the EU27.	↑

Note: DoI – direction of improvement.

4. Results

4.1. Crisis profiling and regime identification

Figure 2 and Appendix A (Table A1 in the online supplemental data) confirm that COVID-19 constitutes the sharpest and most synchronous downturn in the 2009–2024 sample, with 2021–2024 capturing the rebound phase.

In 2020, the annual cross-regional mean change reached −1.01 percentage points (p.p.) for the employment rate and −3.51% for per capita GDP, the most adverse annual averages in the sample (see Table A1 in Appendix A). By contrast, 2014–2019 shows positive overall mean annual changes (+0.67 p.p. for the employment rate; +3.44% for GDP), while 2021–2023 records the strongest rebound (+0.77 p.p.; +8.72%). In 2024, employment remains positive (+0.42 p.p.), but GDP turns slightly negative (−0.62%), indicating a less uniform macroeconomic rebound. Taken together, these regimes justify using 2020 as the crisis year and 2021–2023 as the post-crisis adjustment phase.

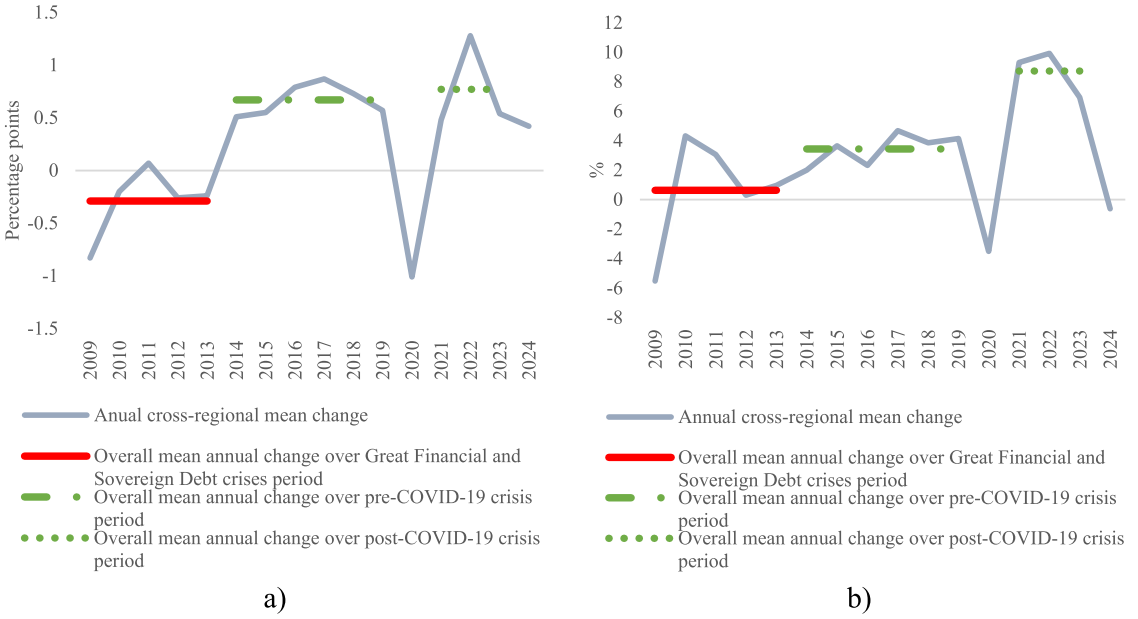

Figure 2. Annual cross-regional mean change and overall mean annual change over different crises and regimes of regional (a) employment rate (ER) and (b) per capita GDP.

4.2. Distribution of resilience profiles across regions

Distribution of regions by resilience type indicates that recovery and, in particular, renewal, as measured by GDP, are more frequently classified as favourable than the other resilience dimensions. In contrast, reorientation emerges as comparatively weaker (more regions with SI < 1) because it captures structural adjustment rather than changes in employment level, as it is operationalised as the change in the average share of high-technology employment between the pre- and post-crisis periods, again relative to EU27. Resistance is also not uniformly strong across regions. Overall, the pattern suggests that regions more often demonstrate a return to, or improvement in, output growth trajectories (especially in GDP terms) than a consistent structural shift.

Renewal also differs by indicator. Favourable GDP-based renewal appears more often than favourable employment-based renewal, suggesting a form of jobless renewal in which output trajectories strengthen more often than employment trajectories. This pattern is consistent with productivity-led adjustment, sectoral compositional change or skills mismatches.

Finally, most regions fall into mixed profiles, while fully favourable profiles across all dimensions are rare. This indicates that resilience is predominantly dimension-specific, often concentrated in recovery and/or GDP-based renewal, rather than uniformly strong across resistance, recovery, reorientation and both renewal measures simultaneously (see Figure 3 and Figure A1 in Appendix A in the online supplemental data).

4.3. Pairwise associations among resilience dimensions

Pairwise Pearson correlations reveal three main patterns: a weak positive association between resistance and recovery, near-zero links between short-term resilience and reorientation, and mixed links with renewal.

The correlations of SIs reveal several important relationships between the short-term and long-term dimensions of regional resilience (see Figure 4). The correlation between resistance and recovery is weak but positive and statistically significant ($r = 0.3013$, $p < 0.01$). This positive relationship implies that regions that experienced deeper employment losses during the COVID-19 shock tended to recover somewhat more strongly afterwards. This pattern is consistent with a 'mechanical rebound' effect: regions most severely affected in 2020 had more scope for rapid post-crisis employment restoration once restrictions were lifted.

The relationship between short-term resilience and long-term structural change, however, remains minimal. Resistance is almost uncorrelated with reorientation ($r = -0.1004$, $p = 0.118$), indicating that the

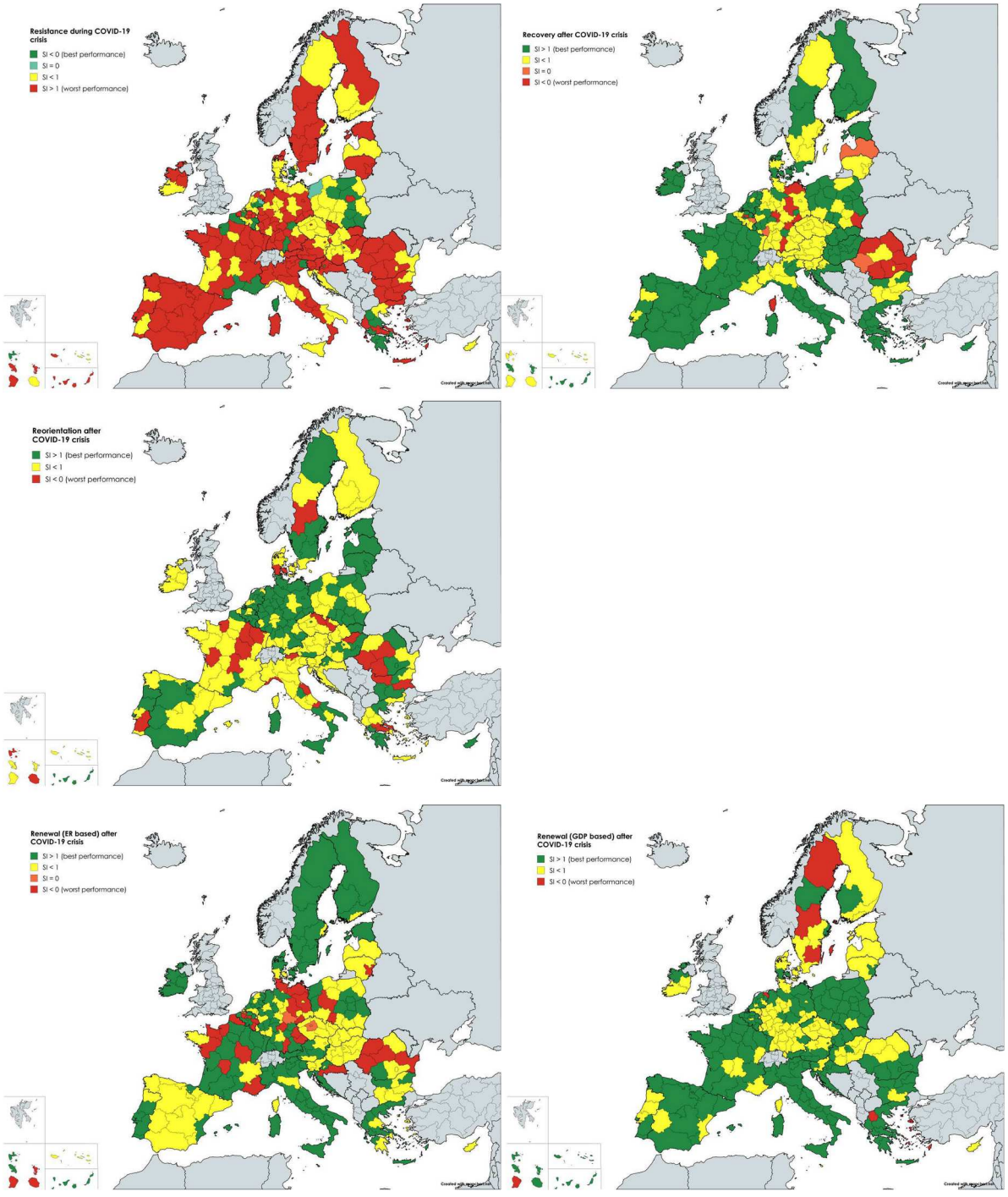

Figure 3. Distribution of NUTS-2 regions based on different dimensions of resilience.

magnitude of the pandemic-induced employment shock had no systematic bearing on the extent of structural upgrading in high-technology employment. Similarly, recovery and reorientation show a negligible relationship ($r = -0.0593$, $p = 0.357$), suggesting that stronger employment rebounds did not necessarily translate into greater sectoral transformation.

The links with renewal are mixed. Recovery is only weakly and marginally positively associated with employment-based renewal ($r = 0.1224$, $p < 0.10$), suggesting that stronger rebounds are accompanied by only slightly more favourable longer-term employment trajectories. Resistance, in contrast, is essentially unrelated to employment-based renewal ($r = -0.0164$, $p = 0.799$). For GDP-based renewal, however, the pattern is more pronounced: resistance is negatively and significantly correlated with renewal (GDP) ($r = -0.2522$, $p < 0.01$). Because better resistance corresponds to lower SI of Res values, this means that regions

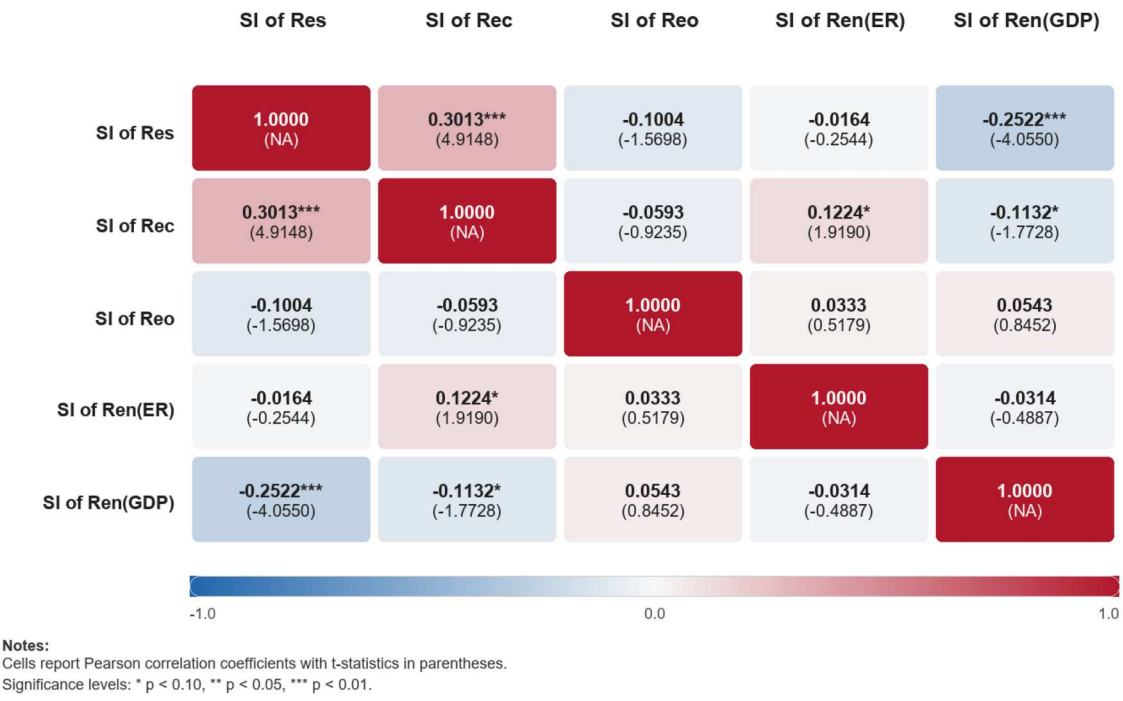

Figure 4. Correlation between SI based on different Resilience dimensions.

that limited initial employment losses more successfully tended to exhibit stronger subsequent GDP renewal. Recovery, by contrast, shows a weak negative association with GDP-based renewal ($r = -0.1132$, $p < 0.10$), indicating that stronger short-term employment rebounds did not translate into stronger long-term GDP trajectories.

Taken together, the results do not support a simple linear progression from short-term shock response to long-term adjustment. Reorientation appears largely independent of both resistance and recovery, while renewal shows differentiated links: better initial resistance is associated with stronger GDP-based renewal, whereas recovery has only weak associations with later renewal, and these differ by indicator.

5. Discussion

The links between short-term resilience and renewal are more mixed than a simple recovery-led interpretation would suggest. Recovery is only weakly and marginally positively associated with employment-based renewal, indicating that stronger post-crisis employment rebounds were accompanied by only slightly more favourable longer-term employment growth trajectories. This suggests that recovery may contribute to later renewal in some cases, but the relationship is limited rather than pronounced. This limited association is important because it shows that employment recovery does not automatically generate a stronger long-term employment trajectory. Rather, recovery seems to matter only when it is supported by deeper productive, institutional and sectoral conditions. The finding is consistent with evidence that renewal depends not only on post-shock rebound but also on whether short-term recovery is supported by stronger productive structures and institutional capacities (Compagnucci et al., 2022; Lazzeretti et al., 2022).

For GDP-based renewal, the pattern differs. Recovery is weakly negative and only marginally significant in relation to GDP-based renewal, indicating that stronger short-term employment rebounds did not translate into stronger long-term GDP renewal. This asymmetry is consistent with evidence that output trajectories are more shaped by productivity improvements than by renewed job creation, especially in regions with more capital-intensive or highly specialised activities (Van Hamme & David, 2026).

Our results also show that the relationship between short-term resistance and long-term renewal is indicator-specific rather than uniform. Resistance is essentially unrelated to employment-based renewal, but it is negatively and significantly associated with GDP-based renewal. This means that regions that limited initial employment losses more successfully tended to exhibit stronger subsequent GDP renewal. Thus,

initial shock absorption appears to matter for later output trajectories, but not necessarily for longer-term employment growth. This distinction suggests that GDP-based renewal may reflect productivity gains, stronger productive structures or capital-intensive adjustment, whereas employment-based renewal captures a different dimension of post-crisis development. This finding partly resonates with previous empirical studies, but also adds nuance to them. Banica et al. (2024) showed that long-term outcomes are shaped by territorial capital and institutional capacity, rather than by the depth of the initial shock alone. Complementing this, Cutrini (2023) found that institutional quality significantly influences post-crisis growth dynamics across European regions, with heterogeneous effects, particularly stronger in peripheral regions than in core areas. Compagnucci et al. (2022) provided similar empirical evidence: higher employment shares in knowledge-intensive sectors are positively associated with better employment performance, while larger shares of high-tech manufacturing, knowledge-intensive services (KIS), and less knowledge-intensive services are negatively associated with low levels of resilience. Their conclusion is particularly relevant for interpreting our GDP-based renewal result, because they show that even a symmetric shock may generate strongly asymmetric regional consequences when regions differ in labour-market structure, KIS and high-tech manufacturing intensity, and fiscal-policy space. They also show that regions in Italy, Spain, Greece and Portugal remained more likely to fall into low-resilience categories after 2008 even after controlling for sectoral composition, suggesting that fiscal constraints and austerity may have reinforced regional divergence. This supports the interpretation that stronger GDP renewal in initially more resistant regions may reflect not only the immediate ability to absorb the shock, but also pre-existing structural advantages and policy conditions that allow regions to convert stability into longer-term output growth.

Against this background, our results suggest that structurally stronger regions may be better positioned to convert initial resistance into GDP-based renewal, but this does not mean that they automatically generate employment-based renewal or structural reorientation. At the same time, the absence of a comparable link to reorientation or employment-based renewal indicates that resistance alone does not guarantee broader adaptive resilience. Long-term renewal, therefore, appears to reflect an interaction between short-term shock absorption and wider structural, institutional and productivity-related conditions.

Taken together, these results highlight a fundamental decoupling between short-term resilience and long-term structural change, but not a complete absence of linkage. Recovery plays only a limited role in employment-based renewal, better resistance is associated with stronger GDP-based renewal, and neither short-term dimension automatically translates into reorientation. This underscores the importance of viewing regional resilience as a multidimensional, temporally layered process, in which short-term stabilisation and long-term transformation are governed by distinct yet sometimes overlapping mechanisms and policy levers. These findings also have direct policy relevance: the weak links between short-term resistance/recovery and longer-term reorientation/renewal suggest that crisis-stabilisation policies should be complemented by instruments aimed at structural upgrading, skills development, innovation capacity and place-based regional transformation.

6. Conclusions, limitations, future research avenues

This study shows that regional economic resilience is not a linear sequence from shock absorption to transformation. Correlations between resistance, recovery, reorientation and renewal are generally weak, indicating a clear decoupling between short-term stabilisation and long-term change. In particular, a stronger post-pandemic recovery does not automatically lead to reorientation, understood as employment shifting toward high-technology sectors, suggesting that many rebounds restore pre-crisis structures rather than upgrading them. The links with renewal are mixed: recovery is only weakly associated with employment-based renewal, whereas better initial resistance is significantly associated with stronger GDP-based renewal. Overall, the findings support an evolutionary perspective in which resilience is temporally layered and mechanism-specific, and they imply that policy must combine short-term protection tools with long-term, place-based strategies that build capabilities and support labour reallocation into knowledge- and technology-intensive activities.

The findings also align with current EU policy debates on Resilience 2.0 (European Commission, 2025), which frame resilience not simply as shock absorption, but as the capacity to support long-term transformation, encompassing reactive crisis management and proactive, structural upgrades that link technological

innovation with regional development. The weak association observed between short-term resistance/recovery and longer-term reorientation/renewal suggests that post-crisis rebounds may restore pre-existing structures without necessarily generating structural upgrading. This underlines the need for temporally layered policies that combine immediate stabilisation with longer-term investments in adaptive capacity, including skills, innovation, institutional quality and labour reallocation towards knowledge- and technology-intensive activities. The strong regional heterogeneity across resilience dimensions further supports place-based policy approaches aimed at strengthening territorial cohesion and reducing uneven transformation capacities across EU regions, strengthening economic, social and territorial cohesion and supporting the 'freedom to stay' by enabling regions to become viable places for long-term employment, investment and social well-being rather than forcing mobility as the main adjustment mechanism.

Limitations and future avenues: reorientation is proxied by high-technology employment, which captures structural upgrading in employment composition but may not fully reflect other transformation channels, such as within-sector innovation, digital upgrading or productivity gains without sectoral labour shifts. Also, the correlation-based design identifies associations among resilience dimensions but does not establish causal mechanisms. In addition, although the results indicate that short- and long-term resilience dimensions are only weakly connected, this study does not estimate the effects of specific determinants within each RER dimension. Different factors are likely to shape resistance, recovery, reorientation and renewal in distinct ways. A key avenue for future research is therefore to model dimension-specific drivers and their heterogeneous effects, using causal designs to identify which policy levers support each resilience stage most effectively.

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Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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